Workshop Booklet
11 January 2017

THE CLIMATE ADAPTATION PLATFORM

Climate Adaptation Workshop

Lead by the Climate Adaptation Platform, New Zealand

Climate Adaptation Platform Partners

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Summary

The Climate Adaptation Platform has been formed in response to the challenge of climate adaptation in Asia Pacific. It brings together New Zealand's leading engineers and researchers in relevant fields, transportation and infrastructure, structural engineering, geotechnical engineering, hydrology and coastal engineering, building management, disaster responses and resilience, to human and developmental sciences and population health. It combines the insights from the latest research with the practical experience of New Zealand's largest engineering and construction consultancies.

Date and time: **Wednesday 11th January 2017 – 2:30pm to 5:00pm**
Location **Room MC9-100, The World Bank, Washington D.C**

Workshop Objectives:

- Introduce the climate adaptation and resilience capability in New Zealand, including the newly formed Climate Adaptation Platform.
- Identify what are the key research questions that still need to be answered
- Identify the priority research areas and topics

Schedule:

National/Country Level

1. *Introduction and Overview of the New Zealand Resilience Framework and the Climate Adaptation Platform*
   Presenter: Dr Theuns Henning – 30 mins
   Synopsis:
   New Zealand as a country is not new to natural disaster events. This presentation briefly summarises the work that has been completed on national level to ensure: "New Zealand's infrastructure is resilient and coordinated *and contributes to economic growth and increased quality of life*."

Regional Level

2. *Overview of Auckland Lifelines Work*
   Presenter: Kerry Griffiths – 15 mins
   Synopsis:
   The regional Life-line initiatives are perhaps one of the most important strategies New Zealand has adopted in order to improve resilience at a regional level. Not all elements of infrastructure require high resilience nor would it be cost effective for infrastructure systems that guarantee supply of services at all times. The life-line project uses criticality indicators, pinch-points and hotspots in order to develop strategies for a region to be better prepared for natural disaster events. This presentation will give an introduction to some of the main Lifeline work strategies.

Local/Micro Level

3. *Valuing Resilience in Infrastructure.*
   Presenter: Monique Cornish - 15 mins
   Synopsis:
   Resilience is universally understood to be a 'good' concept. Improving the ability to prevent, or respond to disruption is objectively desirable. However, the means by which we look to achieve resilience is more subjective and debatable:
   - What do we want to be resilient to?

- How do we prioritise investment to improve resilience to disruption?
- Which stakeholders should be consulted when making decisions about resilience?

This presentation briefly explains the development of an updatable 'decision support tool' to consistently weigh up different controls, to create an acceptable level of resilience in (transport) infrastructure with priority given to desired community outcomes.

Special Technical Topics

4. *Epoxy OGPA, and how it is less temperature susceptible to rutting given rising temperatures*
   Presenter: Phil Herrington (15 minutes)
   Synopsis:
   Climate change is potentially associated with increased frequency of extreme rainfall events and increased average road temperatures, both of which have adverse consequences for road surfacings. Porous asphalt surfacings provide superior drainage and reduced water spray in wet weather but suffer from relatively short lives due to oxidation, the latter is likely to only become a greater problem in the future. This presentation describes the development and properties of an epoxy resin modified, open-graded porous asphalt surfacing that has both high strength and extreme resistance to oxidation, promising lifetimes in excess of 30 years.

5. *Role of Asset Management in climate adaptation and resilience building*
   Presenter: Dr Theuns Henning – 15 mins
   Synopsis:
   This presentation gives an overview of how asset management practices should be modified to ready a road authority for climate change – ranging from modifications of high level policy statements; through to the maintenance of key assets. During the presentation some developments in decision making under uncertainty will also be introduced.

Open Discussion – 30 mins

Presentations

National Resilience & Sustainability

Presenter Dr Theuns Henning

Director Climate Adaptation Platform

Dr Theuns Henning is the Director of the Climate Adaptation Platform, Transportation Research Centre and senior lecturer at the University of Auckland, specialising in the areas of Asset Management, Performance Monitoring, Performance Based Contracts and Benchmarking. Theuns received his ME (Transportation) from the University of Pretoria, South Africa. He has completed his PhD in 2009 at the University of Auckland and was a holder of the Foundation for Research Science and Technology Bright Future Scholarship. His PhD was on the development of pavement deterioration models for the state highways.

Theuns has a significant industry involvement, mostly as Chief Executive of IDS (a company of IPWEA) responsible for the dTIMS project in New Zealand. In this capacity he was responsible for the national state highway long-term maintenance modelling for the past 12 years. He has also recently completed the first regional analysis for the Auckland Transport Network.
Project completed for the World Bank and the Asian Development Bank mostly involved Performance Based Contacting, Asset Management Reviews and the Development of design and decision making guidelines.

Theuns has been the author of 27 international journals, primary author of four RIMS Body of Knowledge guidelines and two World Bank Guidelines for developing countries.

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Sharing New Zealand Experience: National Perspective

11 January 2017

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Agenda

- *Introduction to Climate Adaptation Platform*
- *New Zealand Resilience Framework*
- *Overview of Auckland Lifelines Work*
- *Valuing Resilience in Infrastructure*
- *Epoxy OGPA, and how it is less temperature susceptible to rutting given rising temperatures*
- *Role of Asset Management in climate adaptation and resilience building*

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Introduction of the Climate Adaptation Platform

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The University of Auckland

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Our vision is to be the centre of excellence for climate adaptation in Asia Pacific

- Research into product development and innovation
- Best Practice development (guidelines)
- To offer training and education at all levels
- Solving problems and resource assistance (consulting)
- Post disaster response, recovery and construction

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What makes the University of Auckland an ideal vehicle for the Platform

- Our strategic location within Pacific-Asia
- We have significant resources to offer
- We are already actively contributing in the region
- We have significantly experience in dealing with a changing landscape

Asia and Pacifica is part of us

50% of Students from Asia

10% of our student from pacific Islands

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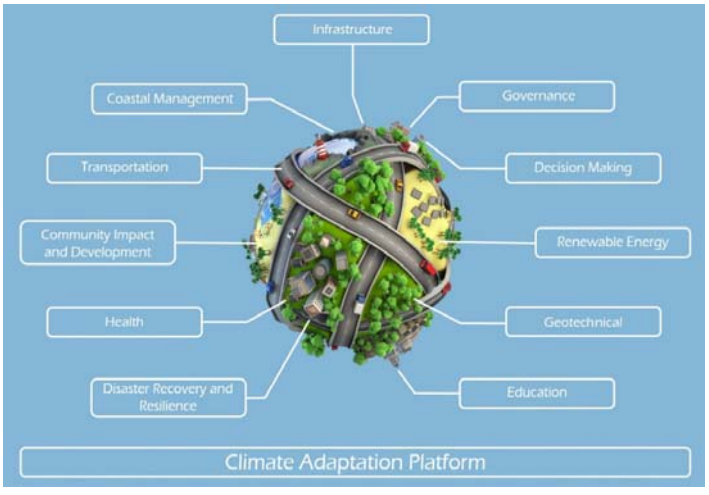
A Multi-dimensional Response



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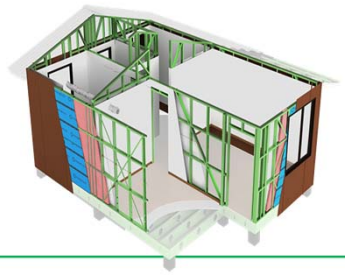
Example: Partnerships Providing Real Solutions



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Option Analyses – Building Resilience for Communities

The Problem

The Options

Original Design

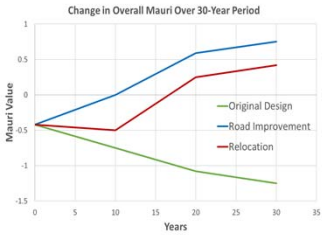
Road Improvement

Relocation

Engineering / Economic Assessment

Risk Cost = Implementation cost x (Probability of Event x Percentage of Road Destroyed) + Maintenance Costs

Social/Cultural Assessment



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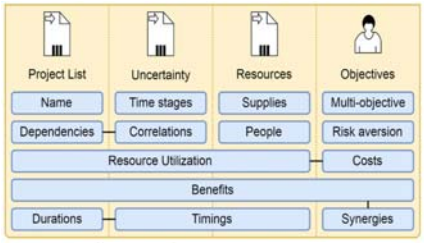
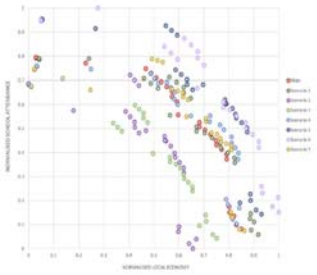
Programme Scheduling Under Uncertainty





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New Zealand's Resilience – National Perspective

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New Zealand is Not New to Disasters and Climate Change

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New Zealand's Resilience a Top Priority

- Office of the Prime Minister - Ministry of Civil Defence & Emergency Management
- Legislation
  - Civil Defence
  - Emergency Management
  - Funding during disasters
- Research (MBIE) – approximate $50 million per year
- Funding (Earthquake Commission - EQC) Crown Entity:
  - provide natural disaster insurance for residential property (contents, dwellings and some coverage of land)
  - administer the Natural Disaster Fund (NDF)
  - fund research and education on natural disasters and ways of reducing their impact

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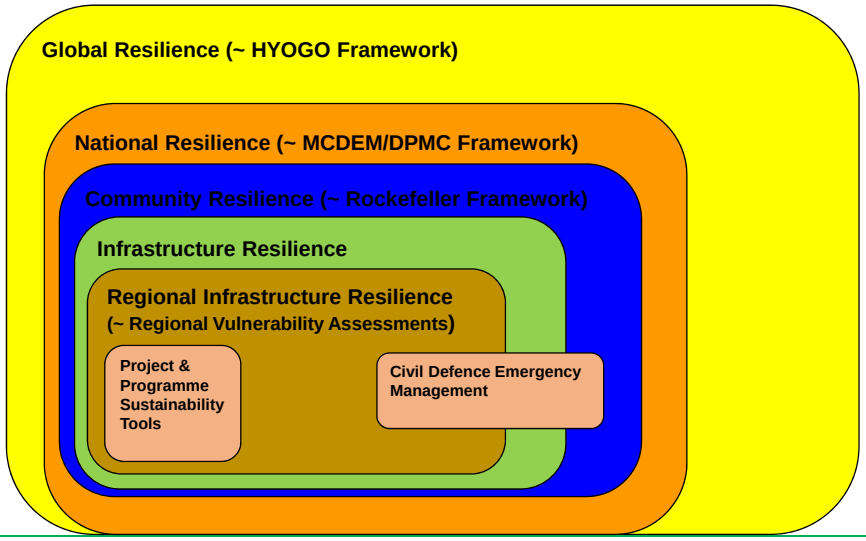
National Resilience Hierarchy ....



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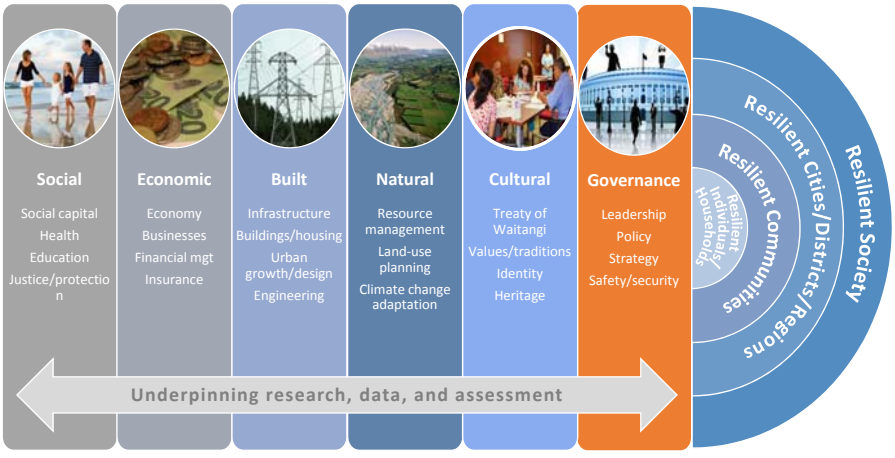
Concept of National Resilience



Source: Ministry of Civil defence and Emergency Management

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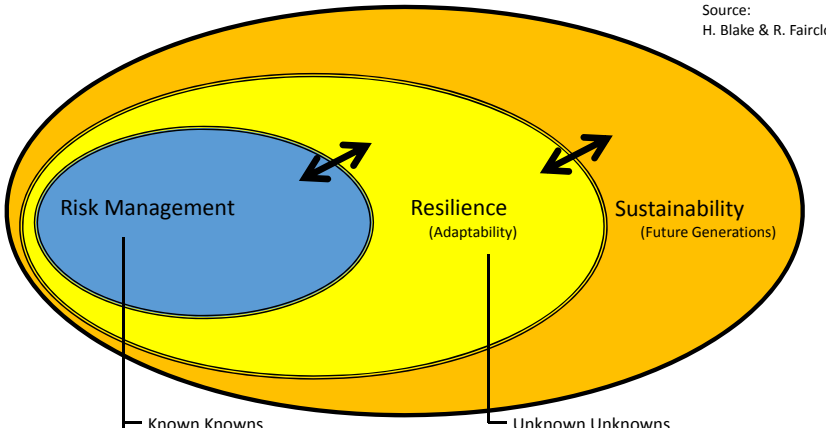
Risk, Resilience and Sustainability …..

Source:
H. Blake & R. Fairclough 2013



Known Knowns
- Variability can be readily described

Known Unknowns
- Limitations, assumptions

Unknown Unknowns
- Black swan
- Threats where you have an adversary
- Complex system risks with dynamic interdependencies

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Sustainability vs Resilience

- RMA (Resource Management Act) focus on sustainability
- CDEM (Civil Defence Emergency Management) focus on sustainability AND resilience
  - Vision "Resilient New Zealand – communities understanding and managing their hazards"
  - Ability to withstand, recover from and thrive after a disaster
- A resilient community is not necessarily a sustainable one
- A sustainable community should also be resilient

RESILIENT NEW ZEALAND VISION

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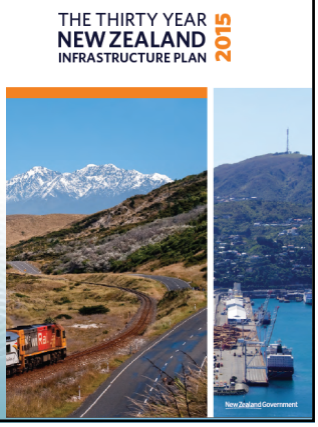
NATIONAL INFRASTRUCTURE UNIT

Thirty Year New Zealand Infrastructure Plan 2015



Vision

- The 2015 Infrastructure Plan provides the vision of:

By 2045 New Zealand's infrastructure is resilient and coordinated and contributes to a strong economy and high living standards

Our infrastructure underpins a **prosperous and inclusive New Zealand** with high quality state services and a healthy and sustainable natural environment. Economic performance is strong with infrastructure that supports **international connectedness, increased productivity, movement up the global value chain, and more exports and growth**. It contributes towards enabling **all New Zealanders to reach their full potential** and play a meaningful role in the economy and society.

New Zealand is supported by a **modern, integrated, and efficient infrastructure system** to make it amongst the most vibrant and exciting places to live and work on the planet, attracting international talent and investment and providing globally recognised goods and services to the rest of the world.

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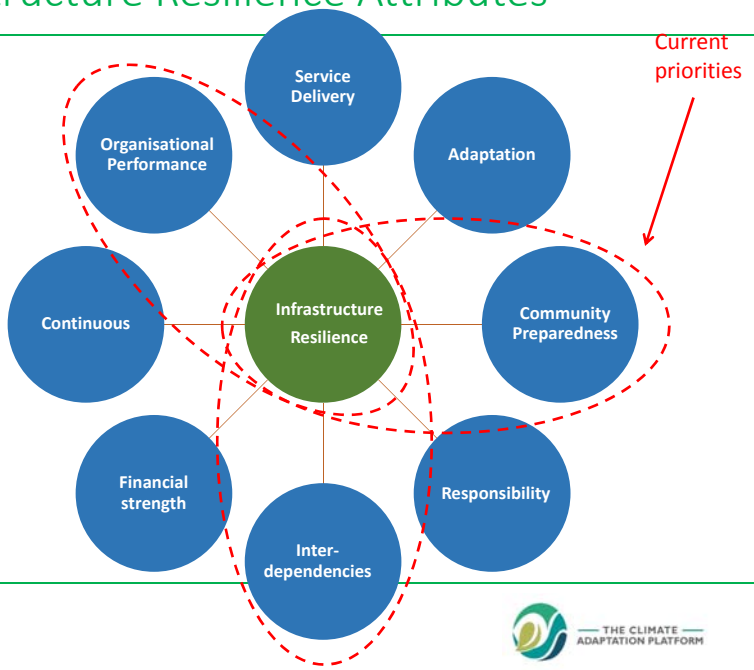
Infrastructure Resilience Attributes



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Resilience Attributes

- Service Delivery
  - Focus on national, business and community needs in the immediate and longer term
- **Adaptation**
  - **National infrastructure has capacity to withstand disruption, absorb disturbance, act effectively in a crisis, and recognises changing conditions over time**
- Community Preparedness
  - Infrastructure providers and users understand the infrastructure outage risks they face and take steps to mitigate these. Aspects of timing, duration, regularity, intensity, and impact tolerance differ over time and between communities
- Responsibility
  - Individual and collaborative responsibilities are clear between owners, operators, users, policy-makers and regulators. Responsibility gaps are addressed
- Interdependencies
  - A systems approach applies to identification and management of risk (including consideration of interdependencies, supply chain and weakest link vulnerabilities
- Financial Strength
  - Financial capacity to deal with investment, significant disruption and changing circumstances
- Continuous
  - On-going resilience activities provide assurance and draws attention to emerging issues, recognising that infrastructure resilience will always be a work in progress
- Organisational Performance
  - Leadership and culture are conducive to resilience, including: Resilience Ethos, Situational Awareness, Management of Keystone Vulnerabilities and Adaptive Capacity. Future skills requirements are being addressed

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Climate Change also Provide Opportunities to NZ

- There are a number of opportunities that could have a positive impact on adapting to climate change and becoming more resilient:
  - Any measure to address resilience would normally address multiple hazards;
  - Some adaptions could be high value for money (e.g. green stabilization of slopes);
  - A more sustainable lens in asset planning would return more value propositions to the country as a whole.

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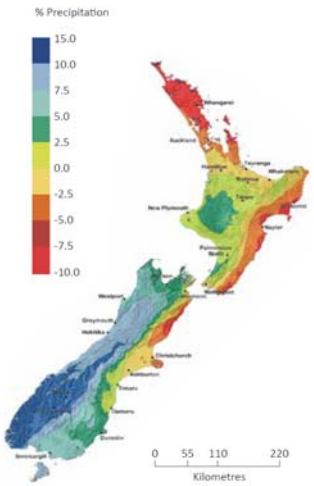
Thank you



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The New Zealand Life Lines

Presenter Kerry Griffiths

Technical Director – Sustainability (AECOM)

Kerry Griffiths is a recognised expert and leader in the sustainability field. She has been involved in the sustainability and corporate social responsibility environment in New Zealand and abroad for nearly 30 years. Kerry works as a Technical Director Sustainability with AECOM and is a PhD candidate at the University of Auckland researching the topic: "Sustainability and Infrastructure – the role of rating tools in driving sustainable outcomes".

Kerry has played a significant role in bringing sustainability practices into the New Zealand infrastructure design and construction industry and has been instrumental in the integration of sustainability considerations in project strategy and delivery on several of the country's iconic infrastructure projects. Kerry has also led teams in the development of sustainability strategies, sustainability reports, baseline assessments, and investigations related to many aspects of sustainability from a technical, stakeholder and change management perspective.

Kerry has played a leading role in the implementation of the 100 Resilient Cities Programme (powered by the Rockefeller Foundation) in Wellington, New Zealand's capital city, and the assessment of the Wellington Region's greenhouse gas inventory using the new Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. As AECOM's delegate for the Sustainable Business Council (SBC), Kerry has contributed significantly including her work with future leaders to develop the SBC's Vision 2050 for a sustainable New Zealand.

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Acknowledgement: Slides provided by Lisa Roberts Programme manager, Auckland Lifelines Group

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Regional Perspective
- Lifelines -

New Zealand Lifelines (Utilities) Council

- Energy, Transport, Telecommunications, & Water
- Supporting resilient communities
- Supporting regional Lifelines Groups
  - Focusing on improving the consistency of output from regional vulnerability assessments
- Providing information to national lifeline utilities to assist them in their resilience work
- Liaising with relevant Government agencies on infrastructure resilience.

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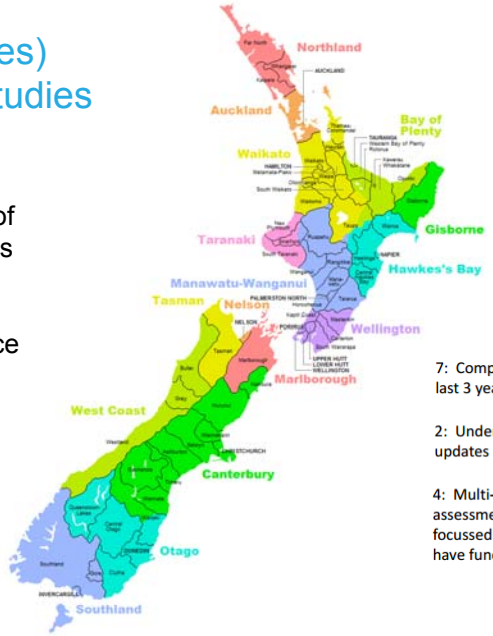
Lifelines (Utilities) Vulnerability Studies

'To assess the potential impacts of hazards on lifelines infrastructure and identify mitigation strategies to reduce that risk.'



7: Completed or updated in last 3 years

2: Underway, some are updates

4: Multi-hazard vulnerability assessment not undertaken (3 focussed on single hazard) – 2 have fund applications in

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Auckland Lifelines Group

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Auckland – Tāmaki Makaurau

- **Population:** 1.495 million; 32% of New Zealand's population
- **Demographics:** Ethnically diverse; majority European; the largest Polynesian city in the world; growing Asian community
- **Geography:** Lies on and around an isthmus; two harbours; about 50 volcanoes.

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Fosters understanding of Auckland's critical infrastructure

Auckland Lifelines

- Ongoing updates as significant infrastructure changes occur

Criticality 1: Nationally Significant
- Failure would cause loss of utility supply to most of region or loss of supply to another nationally significant site that depends on its service.
- Eg: Auckland Airport, Wiri Oil Services Depot, Ardmore/Huia Water Tmt Plants, SH1 / SH16 / SH20

Criticality 2: Regionally Significant
- Failure would cause loss of supply to more than 20,000 customers or reduction in service across the region or loss of supply to a regionally significant site
- Eg: Main cellsite hubs and telephone exchanges, Army Bay (Orewa) Wastewater Tmt Plants

Criticality 3: Locally Significant
- Failure would cause loss of supply to more than 5,000 customers or reduction in service across part the region or loss of supply to a locally significant customer.
- Eg: Smaller community water supplies (eg: Wellsford, Wellsford) and Wastewater tmt plants.

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Fosters understanding of interdependencies – both network and site level

Dependence on	Electricity	Gas	Fuel	Telecomms	Transport	Water / Waste
Lifeline Utility Sector Reliance						
Electricity						
Gas						
Fuel						
Telecommunications						
Road Transport						
Other Transport						
Water						
Wastewater						
Stormwater						
Community Sector Reliance						
Health						
Police						
Fire						
Banking						
Fast Moving Consumer Goods						

Legend	Critical requirement to maintain service continuity during business-as usual.	Some impact on ability to function. Utility becomes more critical in an emergency.	Not required for network operation, though may require for staff needs.

Fosters understanding of infrastructure vulnerability to hazards

Highlights:

- AELP-1: the starting point for the Auckland Lifelines Group
- AELP-2: completed in 2013
- Tsunami, earthquake, volcano, storm, technological failures
- Updated as hazard and lifelines information changes
- Identification of improvement actions drive future business plans.

http://www.aelg.org.nz/document-library/critical-infrastructure-reports/

Fosters understanding of *hotspots* and *pinchpoints*

- **Hotspots:** Where especially significant assets of different infrastructure utilities or sectors are co-located
- **Pinchpoints:** Utility asset or site where a satisfactory alternative route is not available and which is therefore essential to service delivery to *critical sites or facilities*.

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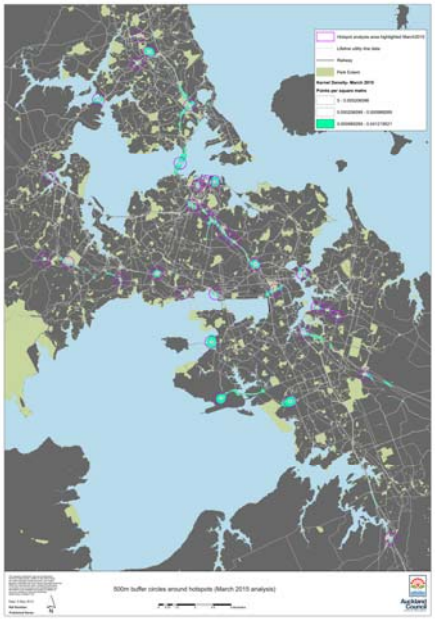
Hotspots and pinchpoints

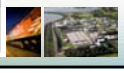


Highlights:

- Updated in 2014/15
- Used GIS 'kernel density' analysis to identify infrastructure hotspots
- Considered hazards posed by other assets as well as by natural hazards in rating overall consequence of failure
- Considered out of region pinchpoints.

Overall conclusions:

- Increased resilience of Auckland's infrastructure – both redundancy and robustness (not quantified)
- Catastrophic failure of hotspot areas is considered very low probability – would require a volcano, meteor, plane crash, terrorism type scenarios.



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Supports research into hazard impacts on infrastructure

Volcanic ash posters for:

- Buildings
- Computers/Electronics
- Gensets / HVAC
- Urban Cleanup
- Airports
- Roads
- Electricity Transmission
- Electricity Generation
- Water Supply
- Wastewater

http://www.aelg.org.nz/document-library/volcanic-ash-impacts/

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Supports research into hazard impacts on infrastructure

- Tsunami impacts on infrastructure
- Joint project with Wellington Lifelines Group
- Funding from Earthquake Commission
- To be made available on ALG website.

http://www.aelg.org.nz/document-library/

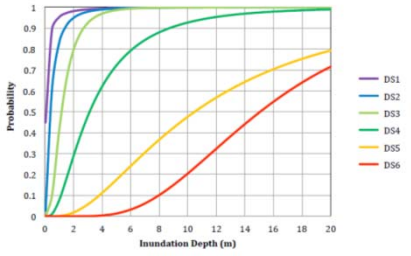


Figure 33 Fragility curve for 3+ storey reinforced concrete building. Source: Suppasri (2013a).

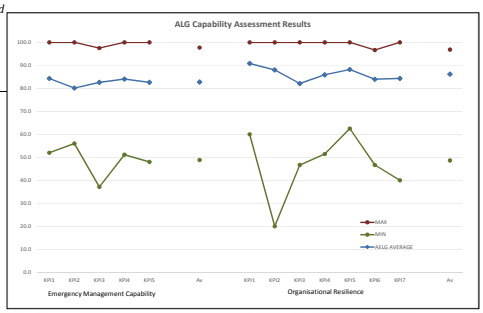
Damage State (DS)	Description
DS1: Minor	Minor flooding, no significant damage to structure
DS2: Moderate	Slight damage to non-structural components and contents
DS3: Major	Heavy damage to some walls but not columns
DS4: Complete	Heavy damage to walls and some columns
DS5: Collapsed	Destructive damage to more than half of walls and columns
DS6: Washed Away	Structure washed away with only foundation remaining

Auckland Lifelines

Coordinates Resilience Benchmarking across the Sector

Emergency Management Capability KPIs
KPI1 Emergency management planning is collaborative and coordinated with CDEM agencies
KPI2 Emergency management planning is collaborative and coordinated with other lifeline utilities
KPI3 Capability to respond to emergencies is developed and maintained
KPI4 Response procedures are pre-determined, documented and tested
KPI5 Recovery policies are planned and implemented

Organisational Resilience KPIs
KPI1 Risk management is comprehensive and integrated throughout the organisation
KPI2 Business Continuity Management has a formalised programme with high-level commitment
KPI3 Critical business functions and processes, and potential impacts on them are defined
KPI4 Business continuity strategies and arrangements are developed and implemented
KPI5 Leadership and culture are enabling of a forward-looking, agile organisation
KPI6 Effective relationships, partnerships and networks are developed
KPI7 Adaptive capacity is fostered through active learning and capability development



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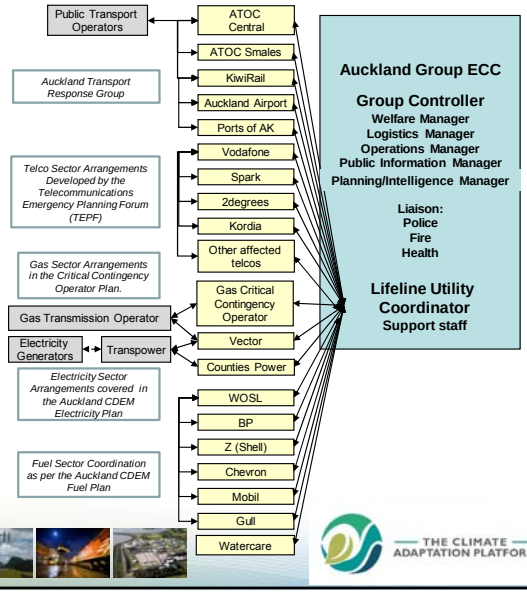
Works with CDEM to support coordination and sector response protocols

- Auckland Fuel Contingency Plan
- Electricity Emergency Communications Plan
- Lifelines Coordination Protocols
- Sector Coordination Entity Protocols
  - Telecommunications
  - Electricity
  - Fuel
  - Transport
- Exercises (Exercise Mayday)



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Valuing resilience in infrastructure

Climate Adaptation Workshop, The World Bank, Washington D.C.



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Research need

- Resilience is a priority for transport
- Improving resilience is desirable
- Current assessment of resilience is subjective
  - What should we be resilient to?
  - Can resilience be valued?
  - How do we prioritise resilience improvements?

"To develop a framework which supports the evaluation of different controls that aim to create an acceptable level of resilience in (transport) infrastructure – in the context of broader social, economic and environmental outcomes - as defined by stakeholders"


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A consolidated definition

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

(adapted by project team for NZTA from USDHS 2009a in AECOM 2015)

Resilience is not restricted to natural hazards: resilience to organisational or systemic challenges is equally important

- Provide for a spectrum of stresses and shocks (the former is often under-estimated)

Confirmed resist, absorb, recover, adapt are the outcomes of resilience and form the basis for the taxonomy

Including tolerance allows the resilience of the system to be placed in the context of the communities value of the function of the system

Takes a wide view of value (which can be weighted if desired, and also allows the inclusion of wider economic benefits)

Focuses on outcomes of the system (e.g. level of service provided) versus *outputs or components* of the system

Resilience should be proactively sought as an outcome of decisioning

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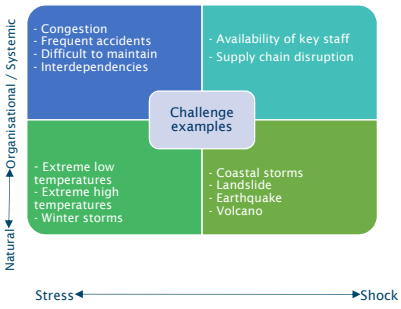
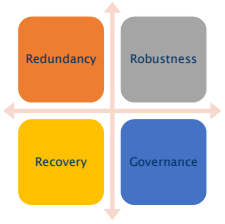
A consolidated taxonomy

An infinite number of scenarios could disrupt a transport network and an equally inordinate amount of controls are available to lower this risk

Challenges: the universe of challenges is large and includes four main dimensions (which work together to form a challenge matrix)



Resilience measures



Controls are equally numerous, but can be transport-centric or non-transport. Overall controls fall into four main categories

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Tool overview

Supports the evaluation of different controls that aim to create an acceptable level of resilience in (transport) infrastructure – in the context of broader social, economic and environmental outcomes - as defined by stakeholders

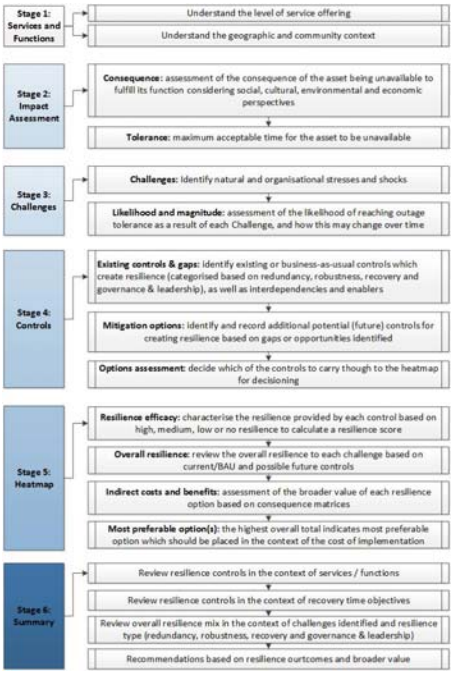
Practical: end-to-end solution for evaluating and responding to risk which can be integrated into existing (NZTA) processes

Leverages work undertaken to-date: explicitly allows for maturity / progression of approach (effort) over time

Outcomes focused: puts the function of assets within a system at the heart of decisioning and focuses on the consequences of assets not being available to users(i.e. not being resilient)

Community focused: allows for a range of stakeholder perspectives to be included in decisioning

Scalable: can be used in other sectors, system versus asset-specific, and can be used to compare investments across different regions



When is this tool useful?

Initial view is that the Decision Support Tool is most appropriate:

- when considering decisions at the asset or project level.
- to narrow down options to solve a particular resilience issue – that is, it can be used to help shape thinking for the strategic / economic business case rather than being used to make final investment decisions (i.e. at the detailed business case stage).

We see value accruing to:

- **Asset owners** could use this tool as a way of better understanding the resilience of assets to different challenges, as well as understanding the impact or benefits that different response measures could have to improve resilience levels.
- **Business Case practitioners** could use the tool as a way of considering the best investments to improve resilience outcomes.
- **Decision makers** could use the Decision Support Tool to consistently consider those transport decisions that will maximise resilience outcomes (as well as understand other indirect cost and benefits).

Decision support tool

Petone Esplanade & Waione Street Bridge Case Study

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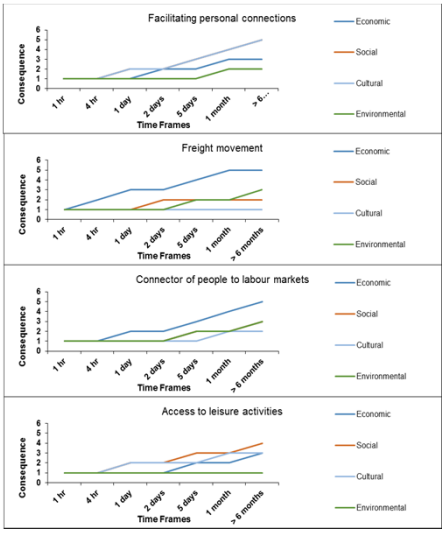
Context

Petone Esplanade & Waione St bridge

- ***Critical Functions***:
  - Links the Hutt Valley/freight to other parts of the region – personal connections and access to labour markets.
  - Key linkage for freight between Seaview/Gracefield and wider region
  - Impedes community access to the waterfront.
  - Serves the Wellington region with bulk liquid fuel supplies
- ***Key Challenges***: Winter Storms, Congestion, Flooding, Tsunami.
- In hypothetical example to the right, overall Recovery Time Objective: 24-hours at 50%



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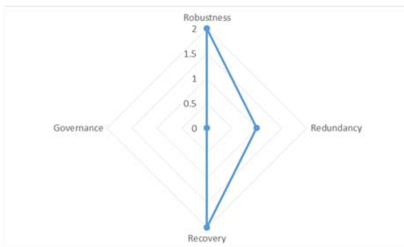
Heatmap

7-Dec-16			Challenge	Challenge	Challenge	Challenge	Challenge	Challenge	Indirect Costs of Control				Indirect Benefits of Control						
	Control	Primary Characteristic	Flooding	Winter storms: snow, ice, hail	Congestion	Earthquake: liquefaction, tsunami, landslide, [illegible]	Landslide	Interdependencies with other assets (operation or maintenance)	Environment	Social	Cultural	Economic	Environment	Social	Cultural	Economic	Total	Cost of control	Source
Current	Stop banks	Robustness through Civil Engineering	L	L	H	L	L	M	M	L	L	L	M	M	L	M	[illegible]	TBC	TBC
Current	Recovery contracts	Recovery through Processes	M	L	L	L	L	L	L	L	L	L	L	L	L	L	[illegible]	$1m	Estimate
Current	Capacity improvements	Robustness through Civil Engineering	L	H	L	L	L	M	M	M	M	M	L	L	L	M	[illegible]	[illegible]	SH2 Ngauranga - Te Marua PBC
Current	Recovery contracts	Recovery through Processes	L	L	L	M	M	L	L	L	L	L	L	L	L	L	[illegible]	[illegible]	Estimate
Future	Communication around working from home	Governance through Information Technology	H	L	H	L	L	L	L	L	L	L	L	M	L	M	[illegible]	$1m	Estimate
Future	Land use change	Governance through People	L	M	L	L	L	L	M	M	M	M	L	L	L	L	[illegible]	$1m	Estimate
Future	Cross Valley Link	Redundancy through Civil Engineering	M	H	L	M	L	M	M	H	M	L	L	H	M	M	[illegible]	[illegible]	CVL Strategic Case
Future	Barge Landing	Redundancy through Civil Engineering	M	L	L	M	M	M	H	L	M	L	L	L	L	M	[illegible]	$100m	Estimate
			10	10	10	8	7	9											



Two new measures score the highest on the total resilience score
- Explore **communication tools** to encourage people to work from home during emergencies.
- Explore **CVL** further

Controls don't materially help mitigate against the challenges the asset is most exposed to

Other controls should be considered
- Further **recovery contracts**
- Higher cost options such as a **barge landing** require considerably more investigation if they are to be justified on resilience grounds alone

Controls recommended focus on **Robustness** and **Recovery** in particular

Next steps

Future Focus Areas

Test

- Opportunities to put research into practice: testing of tool under different scenarios and sensitivity assessment

Implement

- Implementation of tool and development of business rules for NZTA (and other interested parties)
- Opportunities to works with other asset class owners, organisations and jurisdictions

Improve

- Data integration and automation
- Community engagement: ways of effectively engaging with communities to understand tolerance to outage and willingness to pay
- Better measurement of indirect costs and benefits: particularly considering the method to calculate travel time reliability (federal buffer zones)
- Network assessment: consider developing further to be used across a network and between different sorts of assets

Long-life porous asphalt road surfacing

Presenter Philip Herrington

Scientist (Opus International)

Philip Herrington is a Senior Research Scientist with Opus Research (part of Opus International Consultants Ltd). He has an MSc (with distinction) in Chemistry from Victoria University of Wellington and has 30 years' experience of road surfacing and roading materials research and specification development. Phil has published widely in the international scientific literature and has in-depth expertise in the chemistry and rheology of bituminous binders including specialized polymer modified materials such as epoxy modified bitumen. His work centres on the relationship of bitumen physical properties and oxidation chemistry to the in-service performance and durability of asphalt mix and chip seal surfacings.

Phil is currently leading the development of the chip seal binder, performance based bitumen specification for the New Zealand Transport Agency. This specification will be based on test properties closely related to in-service failure modes compared to the current empirical specification. Phil also leads a major 4-year research program in collaboration with the University of Auckland and the New Zealand Transport Agency, aimed at understanding and minimising the effects of water infiltration through road surfacings. New Zealand already experiences relatively high rainfall levels and this is likely to increase in the future due to climate change effects. The project seeks to identify strategies to protect water sensitive unbound granular pavements and prevent water induced damage to the surfacings themselves.

Long-life porous asphalt road surfacing

PR Herrington, D Alabaster, J Waters

THE CLIMATE ADAPTATION PLATFORM

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Fulton Hogan

OPUS

January 2017

Climate change – effects on road surfacings

- Increased average temperatures
- Increased rainfall
- More frequent extreme weather events:
  - High rainfall events
  - Extreme temperatures

Climate change – effects on road surfacings

- **Changing temperature regime**
  - 'Softer' less elastic bitumen at high temperatures
  - Brittle at low temperatures
  - Increased rates of oxidation

→

- Permanent deformation of asphalt mix (rutting)
- Cracking and ravelling (chip loss from the surface)

- **Increased rainfall**

→

- Lower skid resistance
- Reduced visibility (spray)

Climate change – effects on road surfacings

- Epoxy modified open-graded porous asphalt (EMOGPA) is a type of road surfacing material that could potentially help mitigate the effects of climate change

Open-graded porous asphalt mixes (OGPA)

- Advantages:
  - High air voids (20-30%) allows drainage and retention of storm water
  - Maintains skid resistance
  - Reduces spray - improves visibility for drivers

- Disadvantages
  - High air voids facilitate oxidation - hence relatively short lives

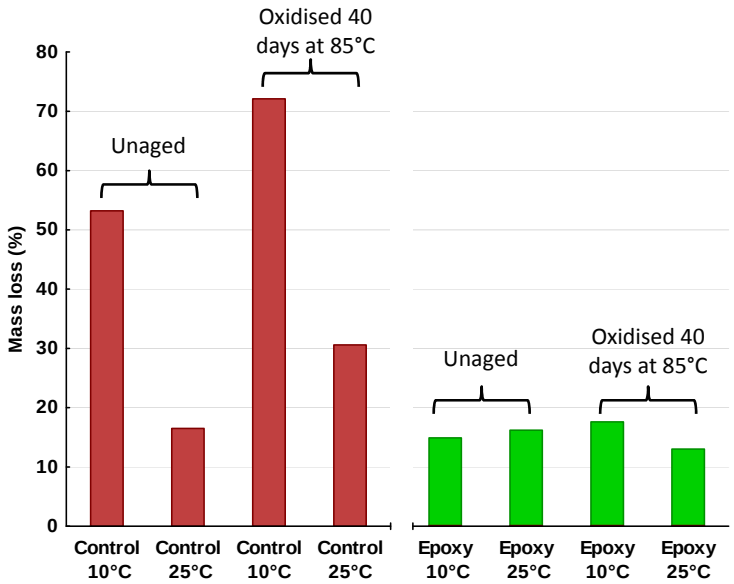
Epoxy modified bitumen

- Epoxy OGPA project began as part of an OECD/ EMCT study on long-life road surfacings
- Two part system, originally developed in the 1960's for specialist applications
- Thermosetting -doesn't 'melt'
- Highly resistant to embrittlement through oxidation
- Non-hazardous, no major set-up costs and only minor operational changes needed
- Costs about 25% more per m^2 in place but 5 fold increase in life expected
- NZ Transport Agency calculate a PWOC value 2.4 times less than standard OGPA

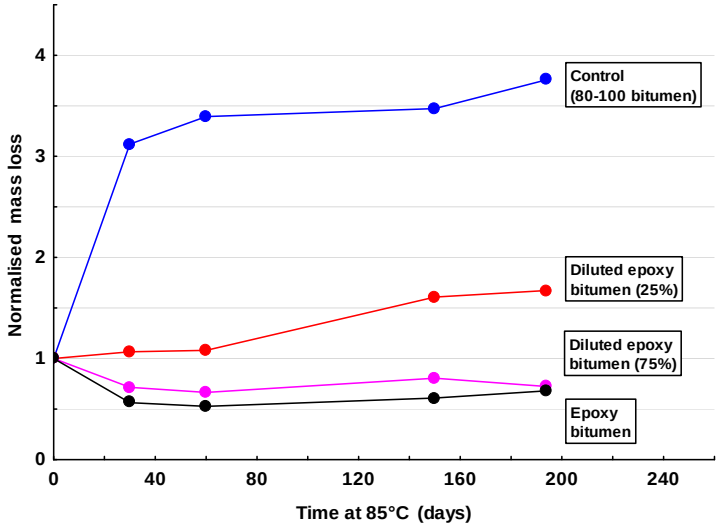
Cohesive strength properties- Cantabro Test

- Cantabro abrasion test
  - 300 revolutions
  - Mass loss measured
- Measure effect of accelerated ageing and temperature

Temperature sensitivity

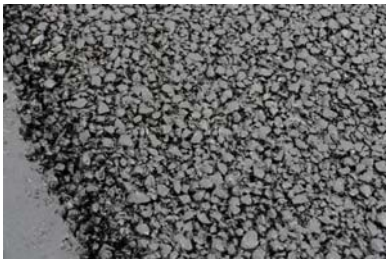


Oxidation resistance

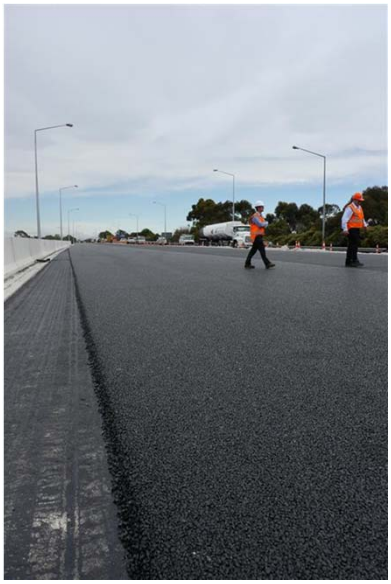


Implementation

- Road trials in 2007 and 2012 Opus/Fulton Hogan/NZTA collaborative development
- Training and dissemination of information to industry through workshops and symposia
- Draft specification written for manufacture and laying and testing (NZTA P11E)
- Several major projects underway



Conclusions



- Climate change will provide challenges to conventional road surfacings through increasing temperatures and rainfall
- Epoxy modified OGPA provides a long-life solution
  - Resistant to deformation
  - Effective rain water drainage
  - Oxidation resistant

Thank You

Contact: Phil.Herrington @Opus.co.nz

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Fulton Hogan

OPUS

Integrating Climate Change into Road Asset Management

Presenter Prof Susan Tighe

Director Centre for Pavement and Transportation Technology (University of Waterloo)

Professor Susan Tighe currently holds an Endowed Chair in Sustainable Pavement Engineering, is a founding member of the Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo. Prior to assuming the Director role which she has held since September 2010, she served as the CPATT Associate Director of Research and Technology from 2005 to 2010. She is a past Canada Research Chair in Pavement and Infrastructure Management. She is a member of the inaugural class of the New College of Scholars of the Royal Society of Canada and was named one of Canada's Top 40 Under 40 for her leadership and vision with respect to the Canadian Transportation Community. She received the Transportation of Canada Academic Merit Award, Inaugural Bleeds Black Award from the Ontario Hot Mix Producers Association and Inaugural Region of Waterloo Top 40 Under 40.

She has successfully completed over 40 graduate students since starting at the University of Waterloo in 2000, many of whom are now in academic, public and private sector leadership positions. She is an author of over 400 technical publications in pavements and infrastructure, including being the principal investigator on the 2013 Transportation Association of Canada Pavement Asset Design and Management Guide and is involved in a number of national and international research projects. She has been involved with projects in Africa, India, Chile, India, China, Australia, New Zealand and throughout North America. Dr. Tighe worked for the Ministry of Transportation Ontario prior to pursuing a career in academia. During sabbaticals she has spent time in Australia working for a contractor, and has also received academic Fellowships including the Erskine Fellowship at the University of Canterbury in New Zealand, the U.K. Royal Academy of Engineering at the University of Nottingham in England and the Queensland Pavement Center located at the University of the Sunshine Coast in Australia.

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Integrating Climate Change into Road Asset Management

Dr Theuns Henning
Dr Ian Greenwood
Prof Susan Tighe

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Core Messages

- Robust Asset Management (AM) in itself, already significant enhances resilience of infrastructure
- Slight adjustments to AM process, significantly contribute to adapting for climate change
- Development Priorities:
  - Collection of relevant data and information first and foremost investment into climate adaptation
  - Vulnerability assessments of road networks need to take a holistic view of multi hazards and other assets types
  - Decision making perhaps the most needed research area (incorporating uncertainty)

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An Excellent Process Fit

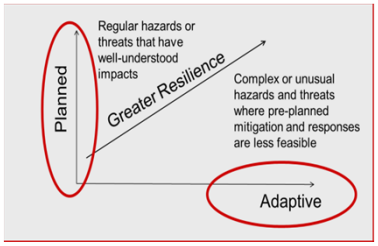
Maintain existing assets to appropriate level of service

Allow for a changing demand & changing climatic conditions

Achieve holistic AM for a better future

Incorporate resilience into planning system to minmise impact of future events

Build back better by using AM to maximise the investment's return



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Governance, Policy and Legislation

- Implementation of climate adaptation would only be successful if executives shows a demonstrably commitment to the process
- Experience showed successful asset management implementation was initiated by creating dedicated AM teams – perhaps the same would be required for climate adaptation
- Significant work still required for post disaster governance aspects:
  - Governance structures (good examples from NZ)
  - Insurance/Funding for events
  - Policy
  - Legislation
  - Contract forms

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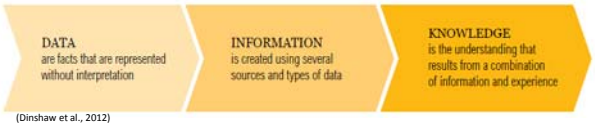
Information



(Dinshaw et al., 2012)

Better data and information assist in better decision making.

- In addition to traditional road related data items also need:
  - Rainfall/Storm and/or other weather impact data
  - Condition/failure risk/ structural health
  - Information on specific risks (e.g land-slides and rock falls)
  - Road function/community socio-economic or cultural activities

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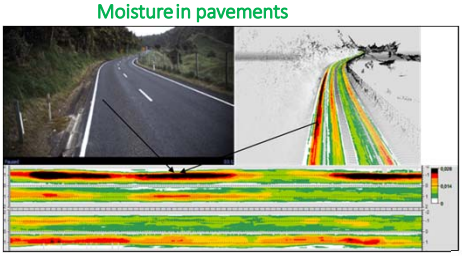
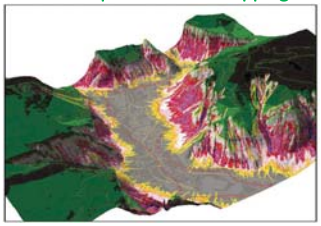
Exciting Developments in Data Collection

Moisture in pavements



Source Arnold, 2016

3-D Geospatial Hazard Mapping



(Guzzetti et al., 2003)

Rapid data collection following events

e.g Haiti (World Bank, 2010)

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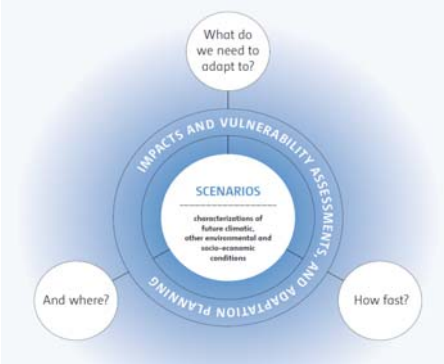
Risk and Vulnerability

(FHA, 2012)

A holistic risk management process is required. Climatic events are just one part of the picture



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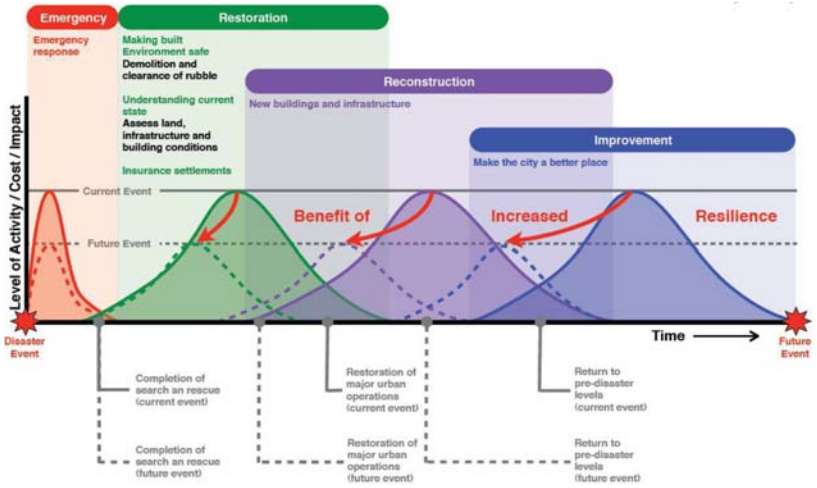
Decision Making towards Resilience



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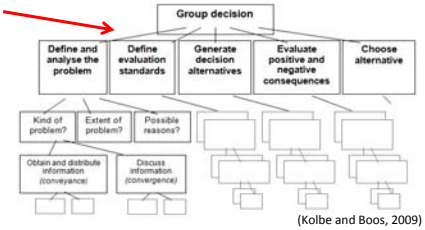
Decision Making Techniques

- There are already a number of techniques available
  - Risk-based methods
  - Delphi decision making
  - Hierarchical and Sequential Structure of Group Decision-Making
  - Traditional Road Management Systems
  - Multi-criteria analysis
  - Multi-objective Optimisation



(Kolbe and Boos, 2009)

- All need to be contextualised for climate adaption

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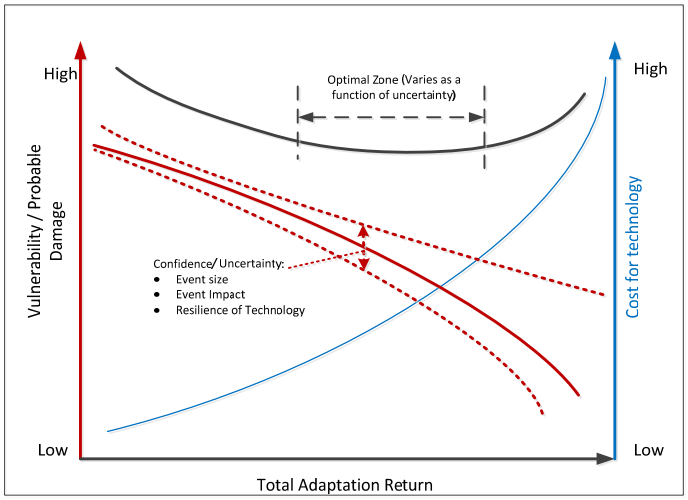
Adopting Resilient Technology



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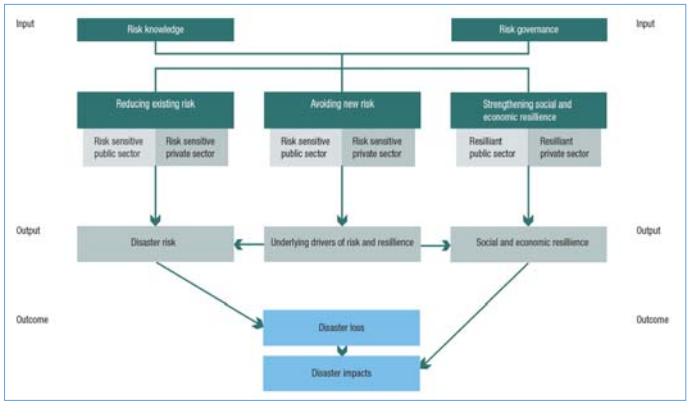
Monitoring Progress on Global and Local Level



Monitor the Progress and/or Benchmark

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Recommendations

- Review the AM process in the context of how climate adaptation measures could be incorporated;
- Explore specific techniques related to data collection & decision making that fits within the problem domain of climate adaptation; and,
- Identify future development issues that will assist more seaming less integration of climate adaptation into asset management processes.

> Climate change is real and it will cost road agencies money. Doing something about the changes proactively will not only mitigate the financial impacts but also result in more resilient communities.

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Thank you

Questions?