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# Bridge Management—Using Structural Health Monitoring

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Tim Heldt, Neal Lake, Joshua Seskis, Hanson Ngo, Edward Eskew

# Agenda

- Structural Health Monitoring – the basics
  - What is it?
  - Why do it?
  - What does it cost?
  - What does it provide?
- Bridge management – the Journey
  - Origins
  - Context and practice
  - Framework and basics
- Bridge assessment – the Options
  - Framing
  - Decision making
- The key to SHM informed bridge management

***Decision mapping is essential  
before SHM activities are scoped***

*Job done*

# SHM – the basics

# Structural Health Monitoring - Definition

- AS5100.7 The use of various sensing devices and ancillary systems to monitor in situ behaviour of a structure to assess the performance of the structure and assess its condition.



# Testing bridges - interesting toys?!!!..but how does it help?



# Why? Example Load Testing/SHM scenarios and trends

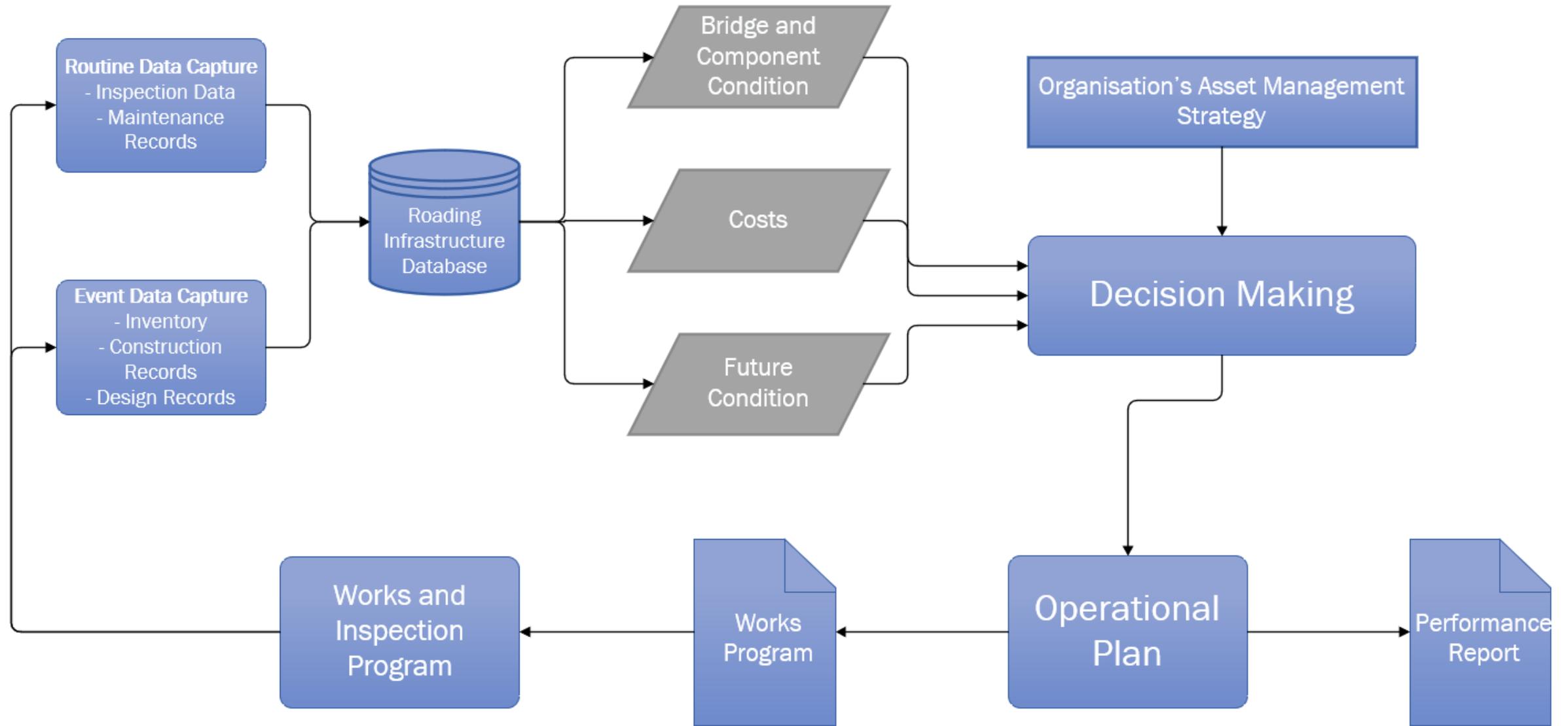
- Local authority RFQ 2017 (Engineering)
  - 50 Bridges – Level 2 and load rating
  - Behavioural tests on all bridges to establish DLA for rating
- Local authority (2018) with defective and critical bridges (AM)
  - Monitoring as part of risk and technical assurance

# Typical Load Testing/SHM project costs & benefits

Rationale	Cost (AUD)	Typical technical focus	Inform decisions regarding
Modal testing	\$5–20 k	Determine bridge dynamic characteristics Boundary conditions and element stiffness Dynamic response verification	Indicative overall stiffness Dynamic response, defects and discontinuities
Behavioural/ diagnostic test	\$30–100 k	Model calibration Indication of change in behaviour	Structural behaviour, load distribution, and assist understanding of credibility gap
Ambient Strain Monitoring	\$50–100 k	Load spectrum and patterns Heavy load events	Structural behaviour, site load profile, distribution, and assist understanding of credibility gap
Proof load test	\$100–500 k	“Finger print” performance and provide indication of change Capacity and risk assurance Due diligence	Minimum structural capacity, assist understanding of credibility gap, – sometimes extrapolated to bridge family

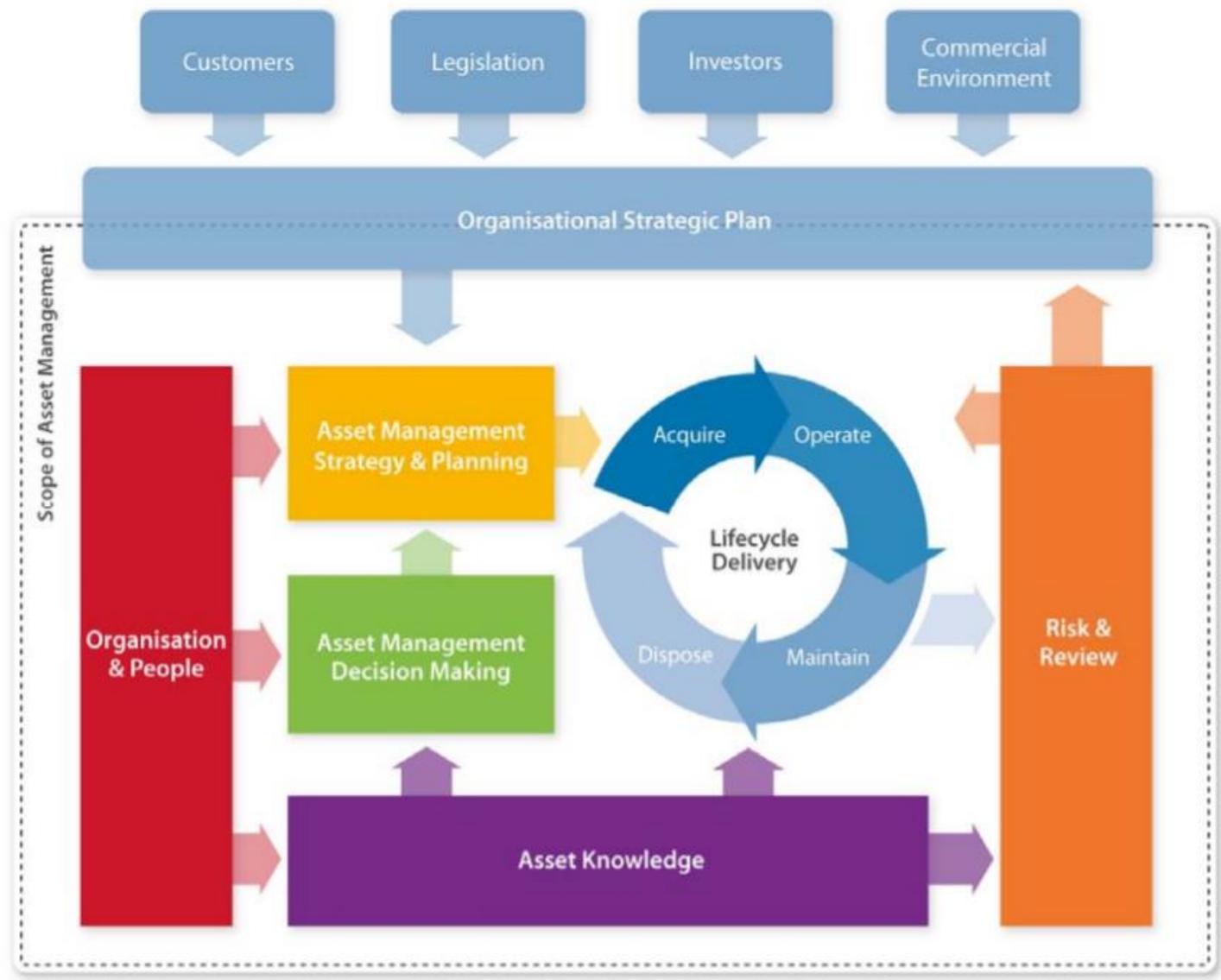
# Bridge Management – the Journey

# Bridge (Maintenance) Management – Current Core Framework – SHM doesn't have a home here...



# Asset Management – Target Core Framework

SHM might fit here if it helps inform AM decision making...

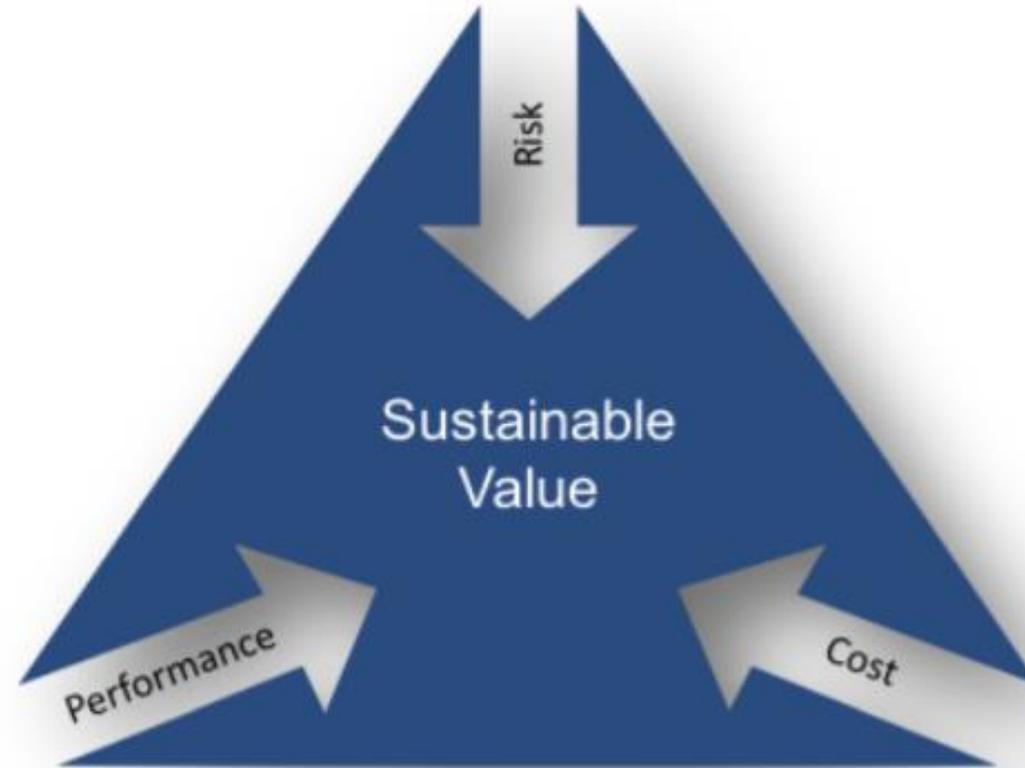


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- Organisation journey required
- Improve existing business processes
- Cultural change
- System development
- Time and investment required – continual improvement

# Asset Management 101...& Bridge Management

- **Cost-Risk-Performance set-point**



# Bridge Management - the evolving journey...

- Bridge Management state of the art
  - Bridge management systems world wide are generally similar and lack AM rigour – *Bridge Maintenance Strategies – A brief comparison among different countries around the world* (Scutaru, M. C. et al, 2018)
  - Data driven bridge management is in its infancy - *Long Term Bridge Performance Program Status and Preliminary Results* (Johnson, B. V., et al, 2018)
  - Bridge risk management needs an overhaul - *Bridge Risk Management: Credibility Gaps* (McCarten, P., 2018)
- AM has impacted other sectors to significant advantage

# Institute of Asset Management maturity rating

Maturity	Description	Typical Bridge Owners
<b>Excellent</b>	Organisation demonstrates leading practice and maximises value consistent with objectives and operating context	
<b>Optimising</b>	Organisation demonstrates systematic and consistent optimisation	
<b>Competent</b>	Organisation demonstrates systematic and consistent delivery	
<b>Developing</b>	Organisation has identified the means of systematically and consistently delivering – credible progress and resource plan	
<b>Aware</b>	Organisation has recognised need, and evidence of intent	
<b>Innocent</b>	Organisation has not recognised the need	

# Bridge Management – Score card 2019...

What we do OK...	What we don't do well...	What does it mean...
Increasing use AM principles	<b>Focus on decision inputs</b>	Limited effectiveness and efficiency
Collect historical data...?	<b>Document decisions</b>	<del>Better decisions faster</del>
Collect condition data	Document basis for decisions	Increased liability
Collect capacity data...?	Link decisions (line of site)	Limited continual improvement

# Bridge Assessment – the Options

# Bridge Assessment – Frameworks to incorporate SHM

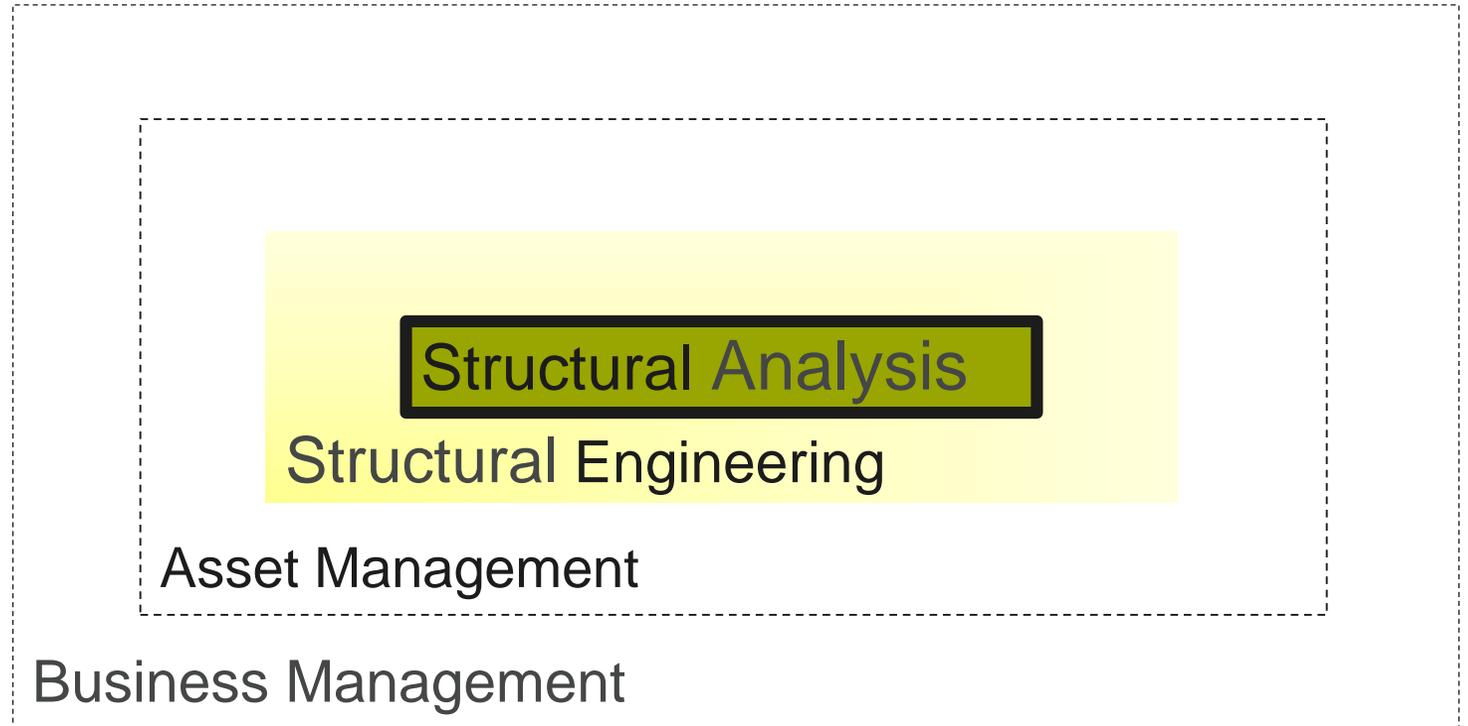
- Technical Framing – AS5100.7
  - Prediction of loads and capacities
  - Underpinned by conventional engineering processes
  - Requires condition to be understood
  - Accommodates the use of load testing/structural health monitoring
- Management framing – AS/ISO13822
  - Risk informed management of assets
  - Cognisant of business outcomes
  - Significant benefits, but requires more sophisticated management processes
- Framing is organisation specific

# AS5100.7 – Process and context – SHM framework?

Assists quantification of structural behaviour

## Process

- Understand condition
- Identify technical factors
- Determine loads
- Determine capacity
- Calculate rating
- Optional refinement
- Report

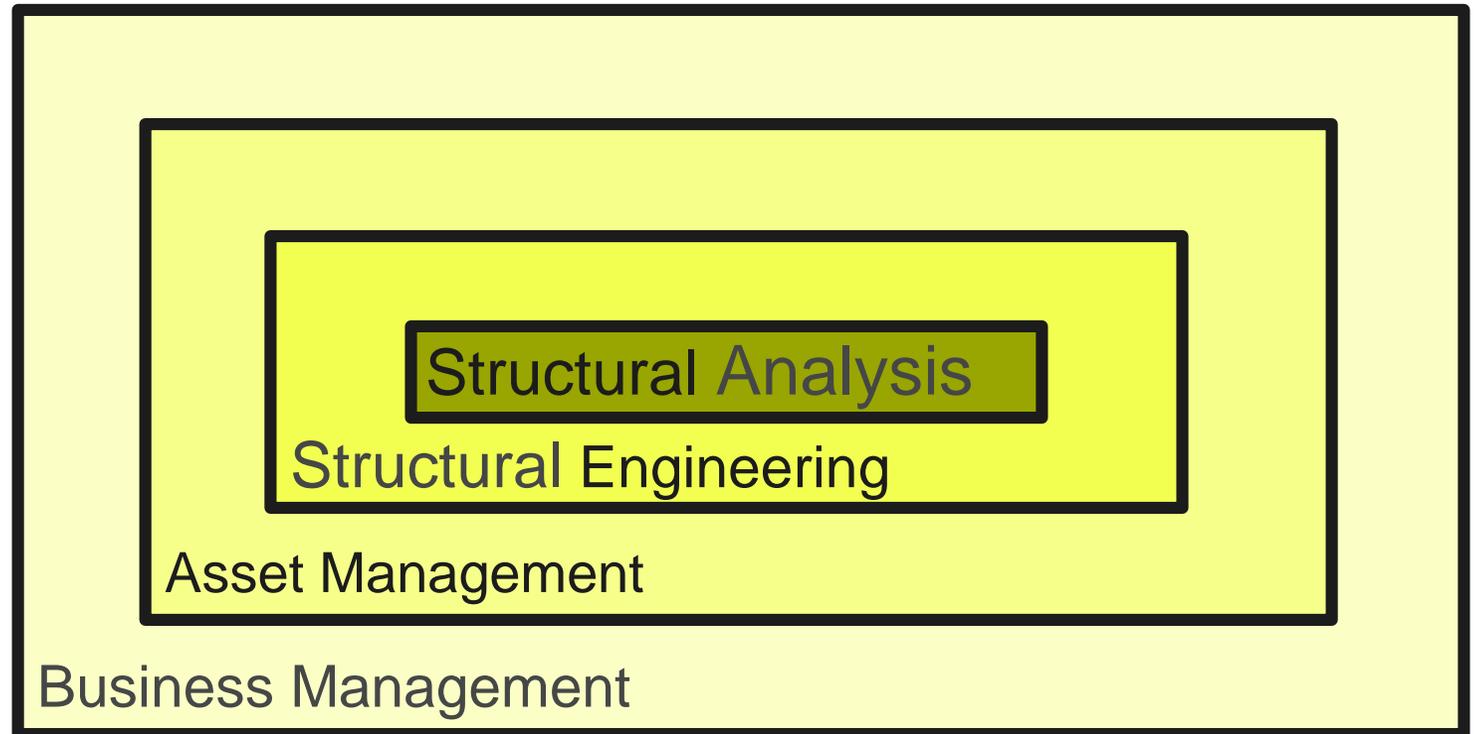


# AS13822 Process and context - SHM Framework?

Assists quantification of risk and performance

## Process

- Define **Objectives**
- Scenarios
- Preliminary assessment
- Detailed assessment
- Report
- Iterate



# SHM can inform decisions...

#	Decision Frame	Attribute quantification
1	Structural analysis	Boundary conditions and element stiffness Frequency response verification Analytical model calibration
2	Structural engineering	Quantification of ambient load profile Probabilistic load assessment Redundancy, Inspectability and Ductility (RID) considerations Reliability prediction
3	Asset management	“Finger print” performance and provide indication of change Risk assurance Due diligence Inform whole of life cost parameters
4	Business management	As for (1) to (3) to meet business objectives

# Where does SHM fit into asset data hierarchy?

- AM Data Hierarchy
  1. Asset register
  2. Specification of functional
  3. Inspection (Condition) records
  4. Capacity records
  5. Maintenance records
  6. **Structural Health Monitoring** records
- SHM has different applications
  - Capital bridges
  - Watchlist bridges
  - Stock standard bridges

# Summary – Bridge Management - use of SHM

- Knowing more technically doesn't help unless it informs better decisions
- **Decision mapping is essential before SHM activities are scoped** – this means
  - Knowing what decisions SHM is trying to inform
  - Knowing what the likely outcomes are, and hence, how the data will be used
  - Targeting of SHM technologies to comprehensively meet objectives
  - Understanding the SHM value proposition
- Industry frameworks are available, but they are not always wisely selected or applied
- SHM can typically inform performance or risk – but comes at a significant cost
- SHM will increasingly be a service to AM in addition to engineering

# Summary – SHM in local government

- Put resources into
  - Inventory and condition data, and act on it – bridge servicing and maintenance is good value
  - Build your maintenance action and cost data – so you can self learn to get better value
  - Assemble the most economical capacity data available – this is the starting point for SHM
- Sharpen the focus on the Performance-Risk-Cost trade-off
  - Understand you the objectives and strategy of your particular organisation – what is priority and what is secondary
  - Balance the risks between functional and technical performance
  - Collect your cost data properly and understand what it means for your LTFP
  - Where and how will SHM add value to the PRC trade-off
- Decision timeframes
  - Knowing what decisions need to be made and when – understand the minimum data inputs for your decisions
  - Stage decision making and procure accordingly
  - Technical input is generally an input to decisions, it may not drive decisions in all cases.

Questions?

The image features a vibrant blue background with a pattern of white dots that form a series of curved lines, creating a sense of motion and depth. In the top left corner, the word "arto" is written in a clean, white, lowercase sans-serif font. Below the logo, a large, light blue, rounded rectangular shape contains the text "SHAPING OUR TRANSPORT FUTURE" in a bold, blue, uppercase sans-serif font.

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