Agenda

- Project overview
- Futureproofing criteria
- Framework
- Assessment approach
- Case studies
Project Overview

• **Aim:**
  – the ‘what, why and how’ of *infrastructure futureproofing*.

• **Main issues** explored include:
  – **Bouncing back** to the original functionality of an infrastructure system following exposure to a major environmental event
    • e.g. UK national rail network following heavy flooding, wind storm or snow events; and
  – **Change management** due to anticipated or unanticipated changes in the infrastructure or its systems in future
    • e.g. a capacity upgrade of an underground train station.

• **Methodology:** literature analysis, industrial workshops, interviews, case studies

• **Intended Outputs:** a framework, an assessment tool, publications
Infrastructure futureproofing

“The process of making provision for future developments, needs or events that impact on particular infrastructure through its current asset management processes (including planning, design and construction).”

(i) **Resilience** to unexpected / uncontrollable events and circumstances

(ii) **Capability** to adapt or respond to changing needs, uses or capacities

Two CSIC partner workshops held in 2014.
## Infrastructure Futureproofing Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>% Response</th>
</tr>
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<tbody>
<tr>
<td>Flexible/Adaptive/Reconfigurable – can change to meet new demands</td>
<td>23.13%</td>
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<tr>
<td>Resilient – able to withstand shocks and recover quickly</td>
<td>17.63%</td>
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<tr>
<td>Reusable/Extendable – can be reused/extended if deteriorated or failed</td>
<td>13.68%</td>
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<tr>
<td>Robust – not overly sensitive to design assumptions</td>
<td>10.72%</td>
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<tr>
<td>Self-reinforcing – works with, rather than against, natural processes</td>
<td>6.91%</td>
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<tr>
<td>Replaceable – can be replaced during or at the end of life</td>
<td>6.06%</td>
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<tr>
<td>Passive – not reliant on operator intervention</td>
<td>5.78%</td>
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<tr>
<td>“Fail soft”/ “Fail safe” – failure won’t make situation worse/be catastrophic</td>
<td>5.50%</td>
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<tr>
<td>“No regrets” – won’t close off potentially attractive alternatives</td>
<td>5.36%</td>
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<tr>
<td>Recyclable/Demolishable – can be recycled/demolished at end of life</td>
<td>5.22%</td>
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*Responses of CSIC futureproofing workshop participants (2014)*
Framework for futureproofing of infrastructure portfolio

ANALYSE REQUIREMENTS
- User Needs
- Business Objectives
- Requirements - business and others
- Stakeholder Analysis
- PESTLE Analysis

ANALYSE CURRENT INFRASTRUCTURE MANAGEMENT PRACTICE
- Operating Conditions
- Performance Targets
- Asset Management Practices
- Maintenance Interventions
- Asset Position in System
- Risk Assessment / Management
- Interdependencies
- Safety & Reliability
- Regulations, Standards, Policies, Procedures

ANALYSE FUTUREPROOFING CONSIDERATIONS
- Futureproofing Criteria
- Future Scenarios
- Risk Assessment of NOT Futureproofing

ANALYSE FUTUREPROOFING STRATEGIES
- Futureproofing related Models
- Options for Futureproofing
- Future Technologies
- Timing of Futureproofing
- Whole Life Value
- Future Asset Life
- Resources and Skills

MODEL FOR FUTUREPROOFING-CONSIDERED INFRASTRUCTURE MANAGEMENT

* See paper for details of two case studies (Dawlish Railway and Heathrow Airport)
Futureproofing Assessment Approach

(This is one part of the overall Infrastructure Futureproofing Framework)

1. Identify key infrastructure assets
2. Identify key futureproofing criteria
3. Conduct futureproofing assessments (weighted)
4. Conduct futureproofing calculations
5. Conduct futureproofing gap analysis

Note: The assessment approach is implemented in MS Excel, which may be referred to as a tool)
Futureproofing assessment case studies

1) Waster water treatment infrastructure

2) Underground (railway) station infrastructure
Liverpool Wastewater Treatment Works (LWwTw) – Futureproofing assessment case study 1

- Costain, United Utilities
- £200m upgrade project
Possible future changes in Liverpool WwTW

- Changes in regulation (OFWAT water quality requirements, World heritage regulation, EU directives etc)
- Changes in budgets & resource allocation (eg. Cuts in operation budgets, OFWAT cuts or increases in possible charges etc)
- Changes in sea level
- Changes in rainfall
- Changes in consumption
- Changes in degree of contamination of water
- Changes in energy prices
- Changing executive values (e.g. embracing a greener more sustainable agenda)
- Disappearing or new suppliers (spare part problems and possibilities for adaption of new technologies)
- Vandalism and riots
- Power cuts
## Results of futureproofing assessment of LWwTW

### Futureproofing Gap Analysis

<table>
<thead>
<tr>
<th>Infrastructure Classification</th>
<th>Comments</th>
<th>Resilient1</th>
<th>Adaptive2</th>
<th>Replaceable3</th>
<th>Reusable4</th>
<th>Operable5</th>
<th>System-stable6</th>
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<td>R1</td>
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</table>

**Criteria**
- R1: Resilient
- R2: Adaptive
- R3: Replaceable
- R4: Reusable
- R5: Operable
- R6: System-stable

**Futureproofing Gap Analysis**
- W – Weighted
- A – Actual (1-10)
- T – Target (1-10)

1 (least futureproof)
10 (most futureproof)

**Gap** = Weighted Target – Weighted Actual
Results of futureproofing assessment of LWwTW

- Overall view of futureproofing (assets vs total futureproofing scores i.e. sum of weighted scores against multi-criteria)
- A – scores for actual futureproofing assessment
- T – scores for futureproofing targets

W – Weighted
A – Actual (1-10)
T – Target (1-10)

1 (least futureproof)
10 (most futureproof)

Gap = Weighted Target – Weighted Actual

The smallest futureproofing gap

One of the biggest futureproofing gaps
Results of futureproofing assessment of LWwTW

Primary Settlement – Pumps - one of the biggest futureproofing gaps

Others/Power Generation - the smallest futureproofing gap

- Asset’s view of futureproofing (assets vs futureproofing scores against multi-criteria)
- A – scores for actual futureproofing assessment
- T – scores for futureproofing targets
Results of futureproofing assessment of LWwTW

- Criteria views of futureproofing (futureproofing scores against multi-criteria vs assets)
- A – scores for actual futureproofing assessment
- T – scores for futureproofing targets
London Underground Camden Town Station – Futureproofing assessment case study 2

(London Underground 2015)
Results of futureproofing assessment of LU CT station

<table>
<thead>
<tr>
<th>Infrastructure Classification</th>
<th>Resilient1</th>
<th>Adaptive2</th>
<th>Replaceable3</th>
<th>Reusable4</th>
<th>Operable5</th>
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<td>9.74</td>
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</tbody>
</table>

Futureproofing Gap Analysis

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T – Target (1-10)

1 (least futureproof)
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Gap = Weighted Target – Weighted Actual
Overall view of futureproofing (assets vs total futureproofing scores i.e. sum of weighted scores against multi-criteria)

- A – scores for actual futureproofing assessment
- T – scores for futureproofing targets
Other case studies

Dawlish Railways
Tested key futureproofing criteria within infrastructure futureproofing framework. For further details, see ICE J. IAM paper.

Heathrow Airport
Tested key futureproofing criteria within infrastructure futureproofing framework. For further details, see ICE J. IAM paper.

Pakistan Railways
Resilience assessment of railway infrastructure e.g. Tracks, stations (MPhil dissertation)

Crossrail
Futureproofing assessment of underground infrastructure e.g. tunnels and pumps.
Futureproofing assessment approach – lessons learnt

• The assessment approach could provide a dashboard for futureproofing gap analysis at various levels
  • Strategic infrastructure planning – criteria views are helpful
  • Asset-level planning – asset views are helpful
• Benefit areas include: risk assessment / management / registers, stakeholder management, risk management, Future (upgrade) projects planning, BIM
• Assessment criteria needs contextualisation for meaningful assessment

“During the past 12 months I have been working with CSIC and been introduced to the concept of infrastructure futureproofing and the benefits it can achieve when developing solutions for use in the water industry. The use of CSIC’s infrastructure futureproofing tool provides real value in the assessment of the suitability of assets when considering the design of upgrades and new facilities for long-term use and maintenance. The use of the tool should help with the selection of a variety of water and wastewater process asset upgrades thus helping drive innovation and improvement in the industry for future projects.”

Andy Fielding, Performance Manager for Costain Water Sector
Impact

Best Poster Award during IAM Annual Conference 2015, held in Brighton (6/2015).
Two sessions on futureproofing during IAM Annual Conference 2014, held in Liverpool (organised 6/2014).

Outcomes of CSIC industrial workshops on futureproofing (presented and published 8/2014).

Article on infrastructure futureproofing (published 6/2015).

Futureproofing case studies to support development of CEN ACC-CG Guide 4 Adaptation Supplement (submitted through LU 6/2015).

Liverpool Waste water Treatment case study on futureproofing, and endorsement from Costain (published 4/2015).

Infrastructure futureproofing framework along with case studies of Dawlish Railway and Heathrow Airport (submitted 5/2015).
Conclusions

• To date, a meaningful criteria/metric for futureproofing has not been formally embedded into existing options appraisal and asset management processes.

• A structured framework, criteria and a tool for infrastructure futureproofing are proposed with key elements of resilience, adaptability, replace ability, reusability, operability and system stability.

• Case studies suggest benefits in improving current risk assessment / management, stakeholder management, operations & maintenance management and future projects planning processes.
What’s next?

• Additional case studies
  – Via academics/researchers (e.g. Costain is interested in applying the framework/assessment approach in their highways business)
  – Via students (an MPhil dissertation on futureproofing/resilience is completed in 2014/15)
• Consultancy via IfM ECS
• Further research proposals (e.g. EPSRC, Innovate UK, Industry funded)
Acknowledgements
infrastructure
futureproofing