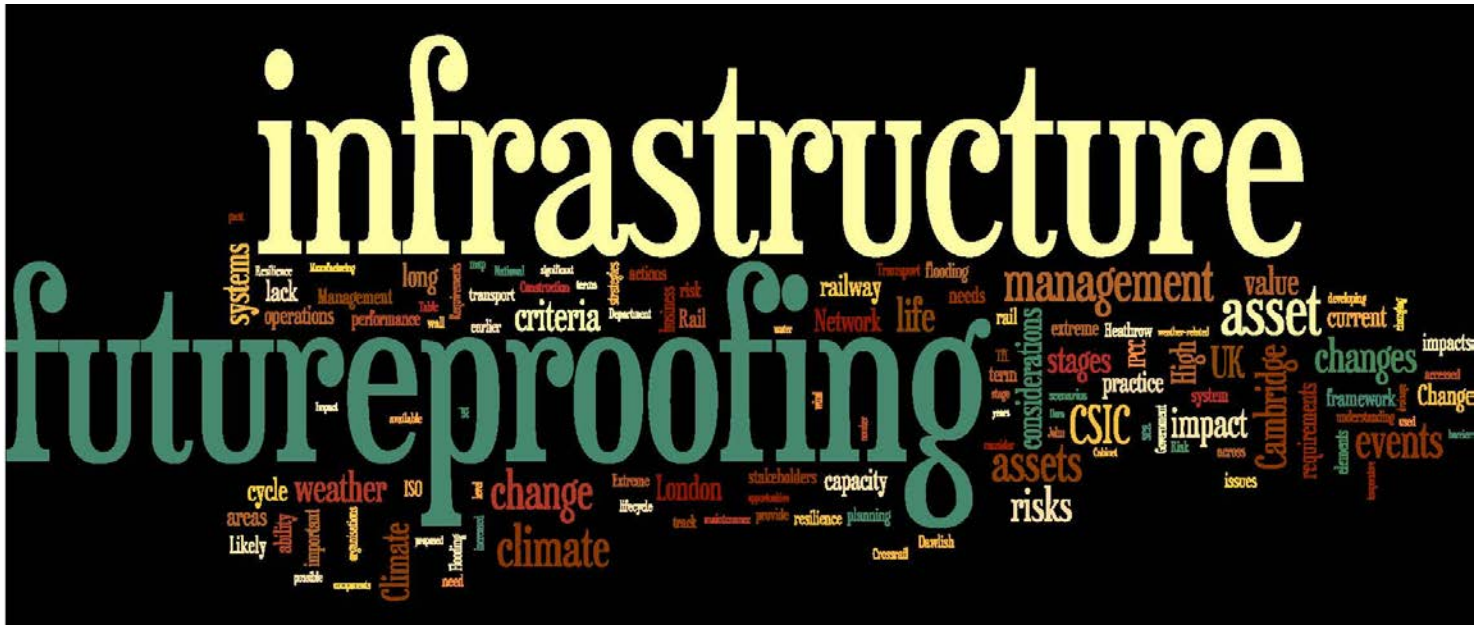

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University of Cambridge

28 September 2015

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CSIC Cambridge Centre for Smart Infrastructure and Construction

EPSRC Engineering and Physical Sciences Research Council

Innovate UK Technology Strategy Board

UNIVERSITY OF CAMBRIDGE

Agenda

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

Project Overview

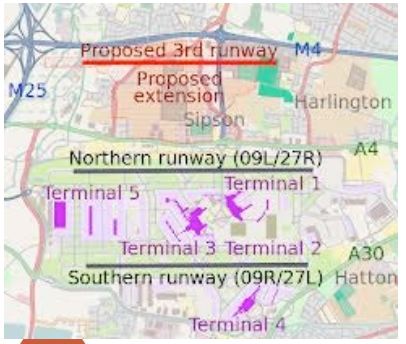
- **Aim:**
  - the 'what, why and how' of *infrastructure futureproofing*.
- **Main issues** explored include:
  - Bouncing back to the original functionality of an infrastructure system following exposure to a major environmental event
    - e.g. UK national rail network following heavy flooding, wind 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)."

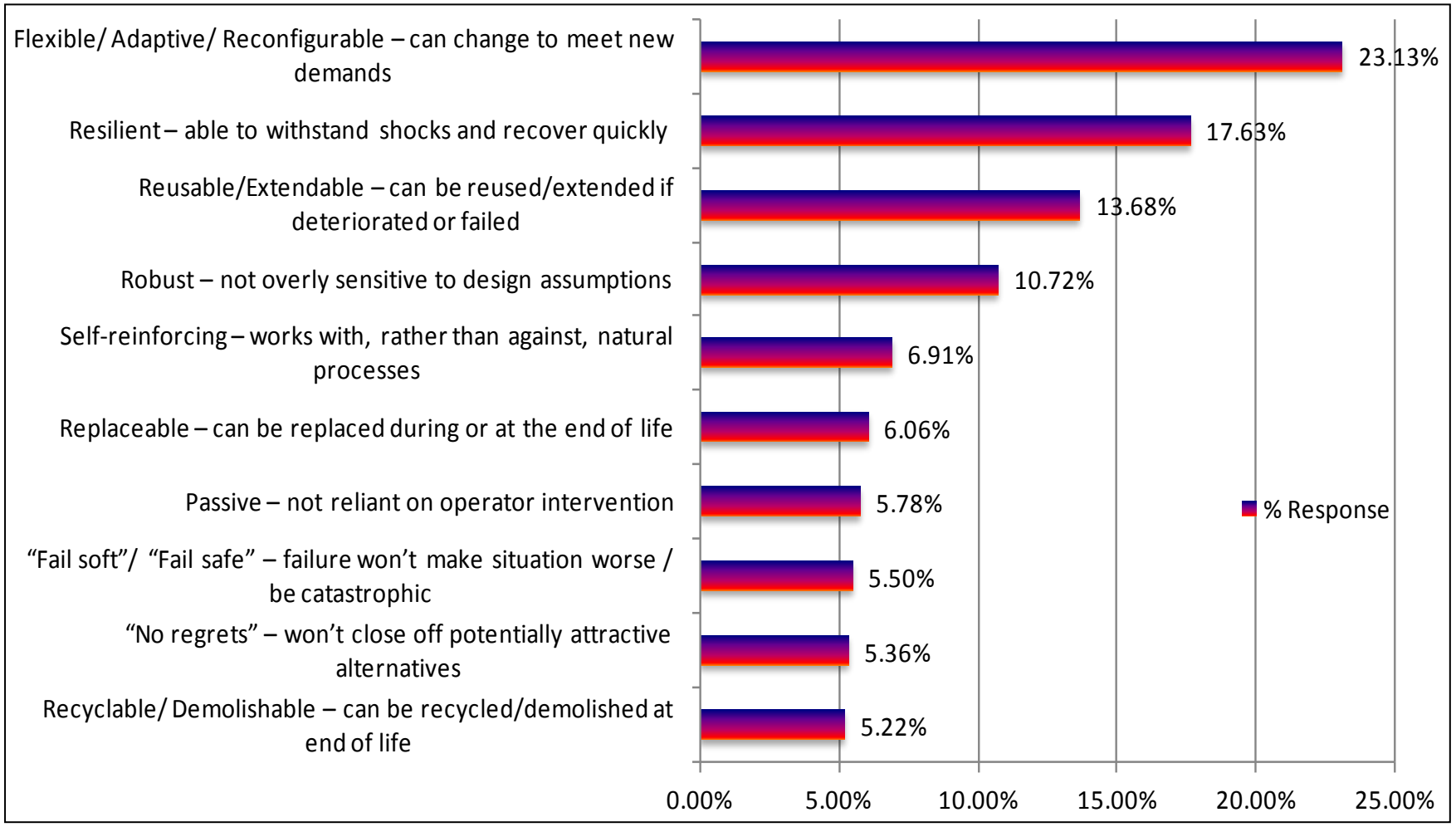
(i) **Resilience** to unexpected / uncontrollable events and circumstances

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



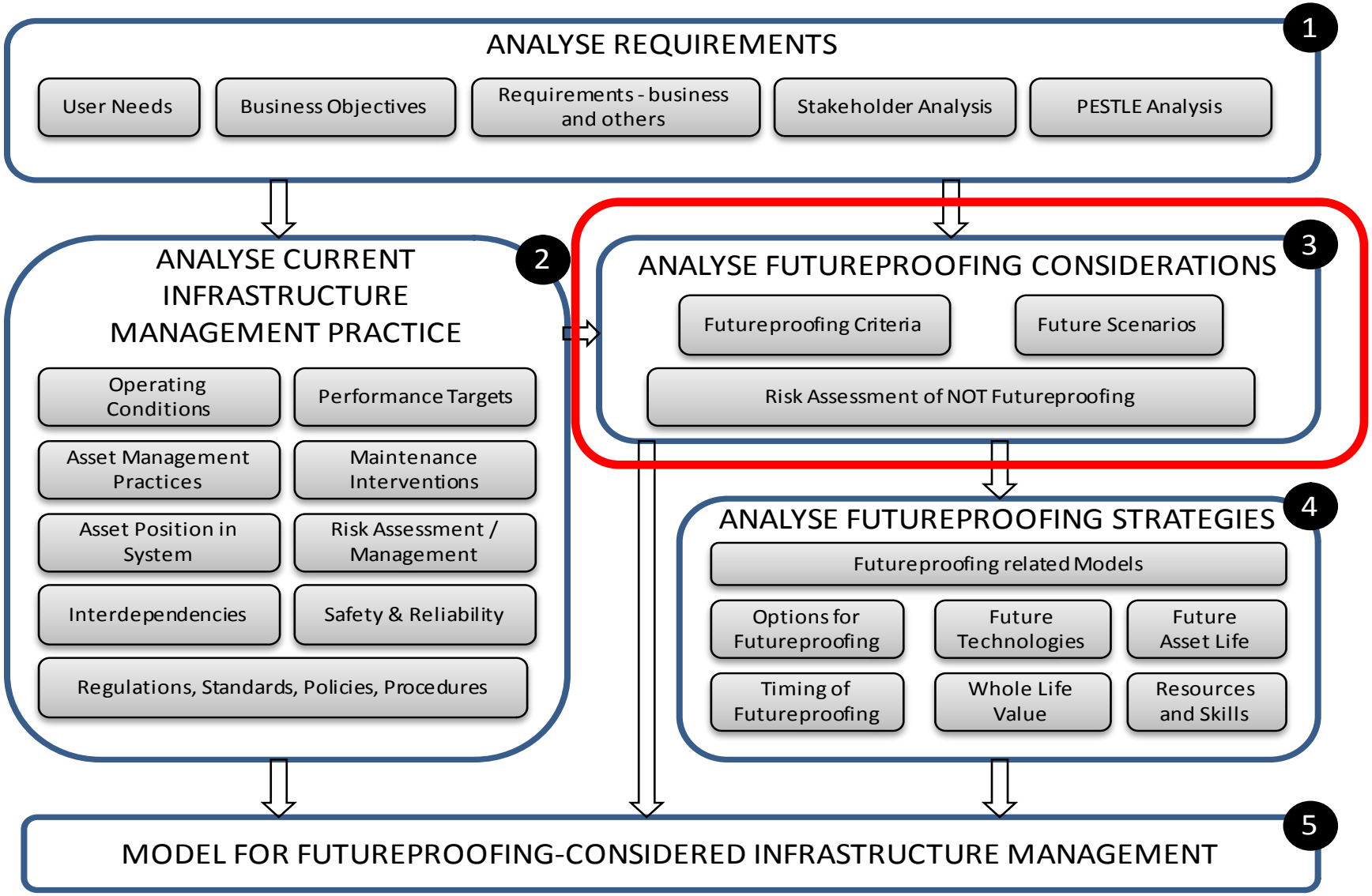
Two CSIC partner workshops held in 2014.

Infrastructure Futureproofing Criteria



* Responses of CSIC futureproofing workshop participants (2014)

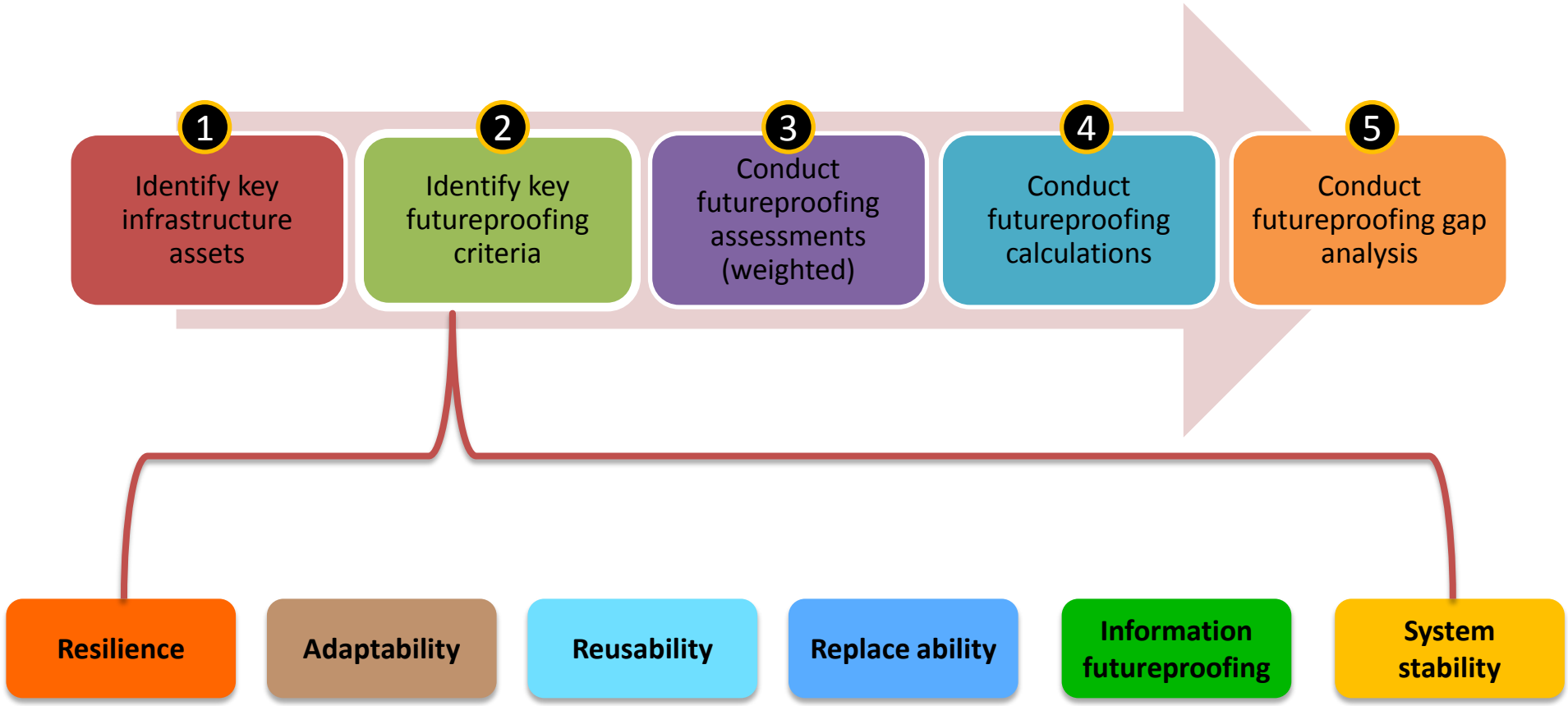
Framework for futureproofing of infrastructure portfolio



* 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)



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

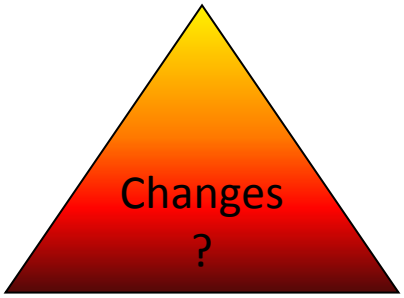
2) Underground (railway) station infrastructure

Liverpool Wastewater Treatment Works (LWwTw) – Futureproofing assessment case study 1

- Costain, United Utilities
- £200m upgrade project

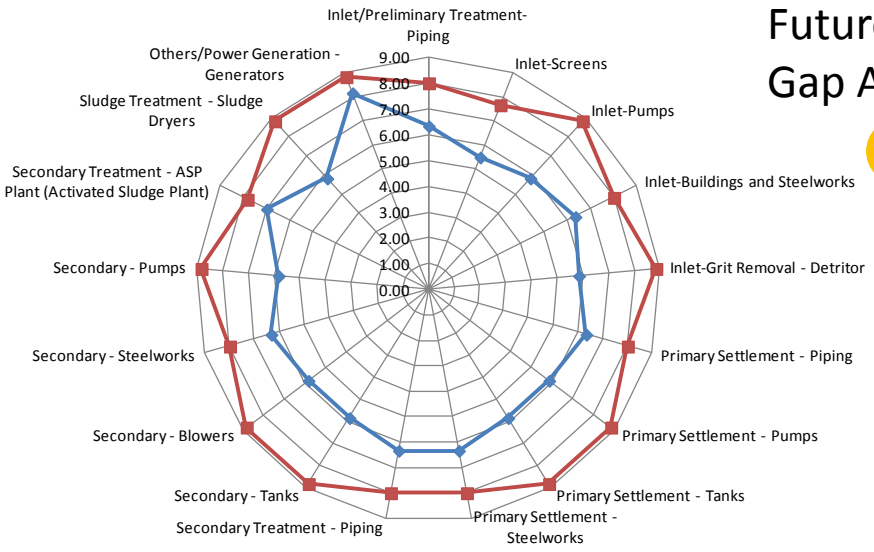
Possible future changes in Liverpool WwTW

- 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

		Criteria																				
Innfrastructure Classification	**Comments**	**Resilient1**			**Adaptive2**			**Replaceable3**			**Reusable4**			**Operable5**			**System-stable6**				**FPN**	
		R1				**A**			**R2**			**R3**			**O**			**S**					
Asset Classification		**W**	**A**	**T**	**W**	**A**	**T**	**W**	**A**	**T**	**W**	**A**	**T**	**W**	**A**	**T**	**W**	**A**	**T**	**W total**	**A**	**T**
Inlet/Preliminary Treatment-Piping		0.17		10	0.17	5	8	0.17	5	8	0.17	2	2	0.17	8	10	0.17	10	10	1	6.33	8.00
Inlet-Screens		0.17		8	0.17	7	8	0.17	10	10	0.17	2	2	0.17	6	8	0.17	4	10	1	5.50	7.67
Inlet-Pumps		0.17		8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Inlet-Buildings and Steelworks		0.17	8	10	0.17	5	8	0.17	5	8	0.17	2	2	0.17	8	10	0.17	10	10	1	6.33	8.00
Inlet-Grit Removal - Detritor		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Primary Settlement - Piping		0.17	8	10	0.17	5	8	0.17	5	8	0.17	2	2	0.17	8	10	0.17	10	10	1	6.33	8.00
Primary Settlement - Pumps		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Primary Settlement - Tanks		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Primary Settlement - Steelworks		0.17	8	10	0.17	5	8	0.17	5	8	0.17	2	2	0.17	8	10	0.17	10	10	1	6.33	8.00
Secondary Treatment - Piping		0.17	8	10	0.17	5	8	0.17	5	8	0.17	2	2	0.17	8	10	0.17	10	10	1	6.33	8.00
Secondary - Tanks		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Secondary - Blowers		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Secondary - Steelworks		0.17	8	10	0.17	5	8	0.17	5	8	0.17	2	2	0.17	8	10	0.17	10	10	1	6.33	8.00
Secondary - Pumps		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Secondary Treatment - ASP Plant (Activated Sludge Plant)		0.17	8	10	0.17	8	8	0.17	8	8	0.17	2	3	0.17	8	8	0.17	8	10	1	7.00	7.83
Sludge Treatment - Sludge Dryers		0.17	5	8	0.17	5	8	0.17	7	10	0.17	2	7	0.17	8	10	0.17	8	10	1	5.83	8.83
Others/Power Generation - Generators		0.17	9	10	0.17	8	8	0.17	8	8	0.17	8	8	0.17	8	9	0.17	8	10	1	8.17	8.83



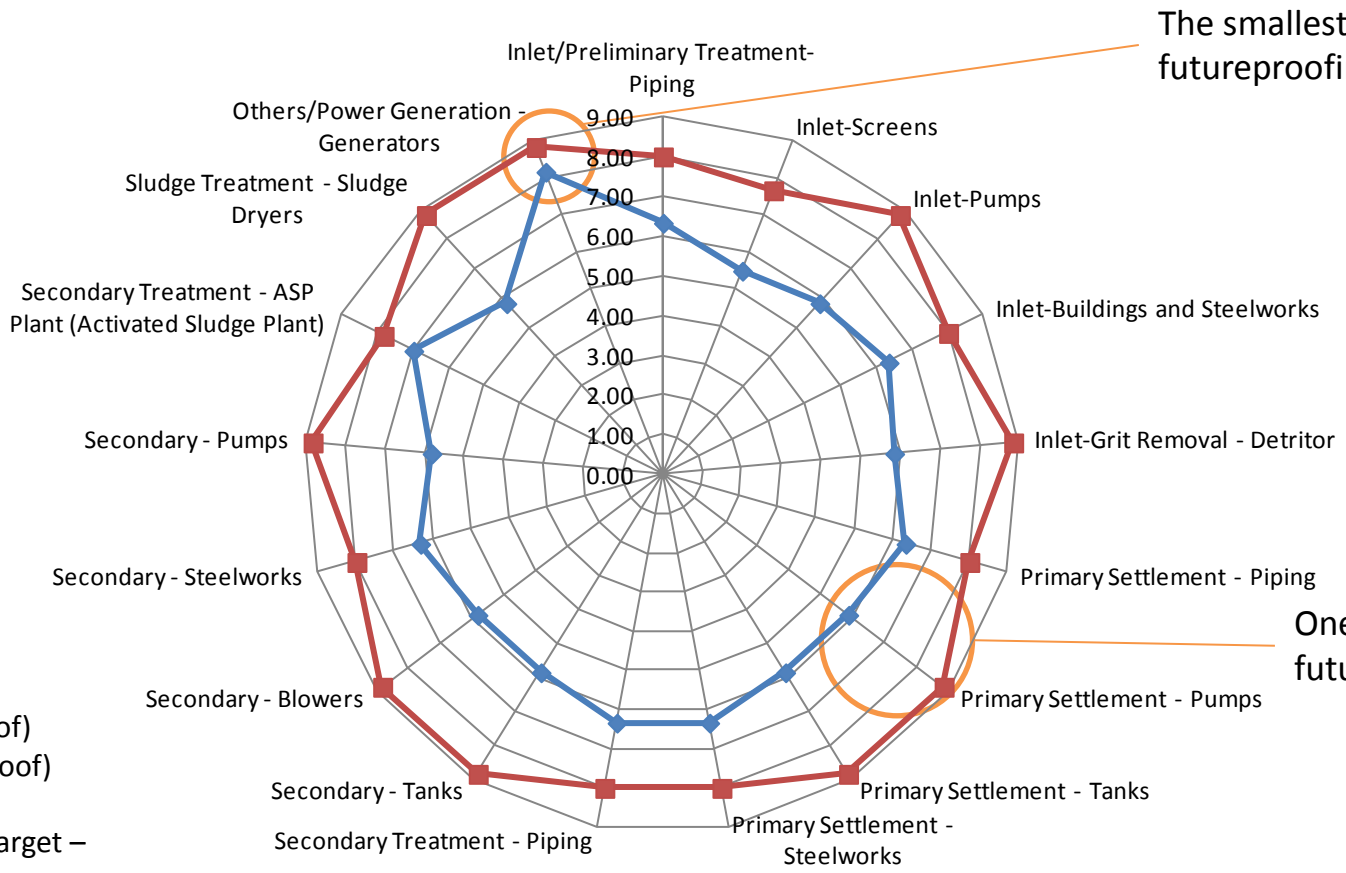
Futureproofing Gap Analysis

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



The smallest futureproofing gap

One of the biggest futureproofing gaps

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

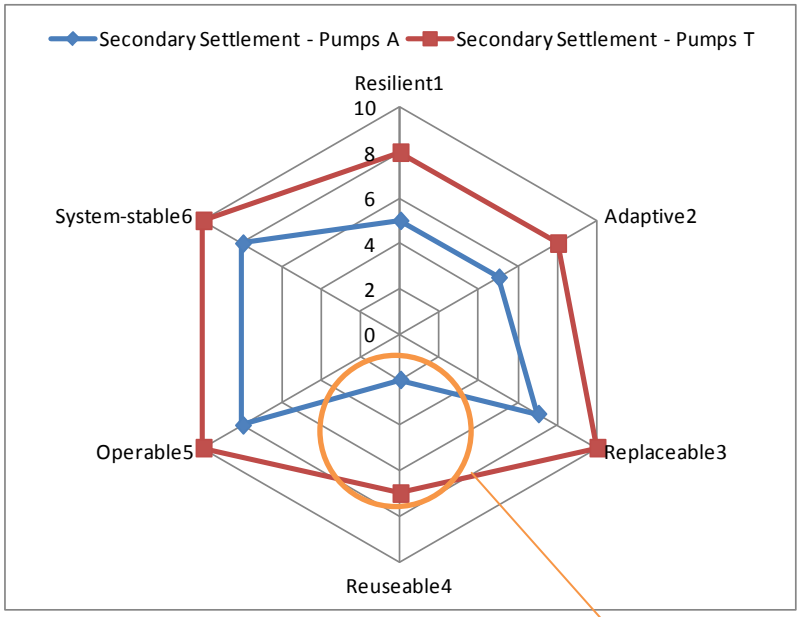
1 (least futureproof)
10 (most futureproof)

Gap = Weighted Target – Weighted Actual

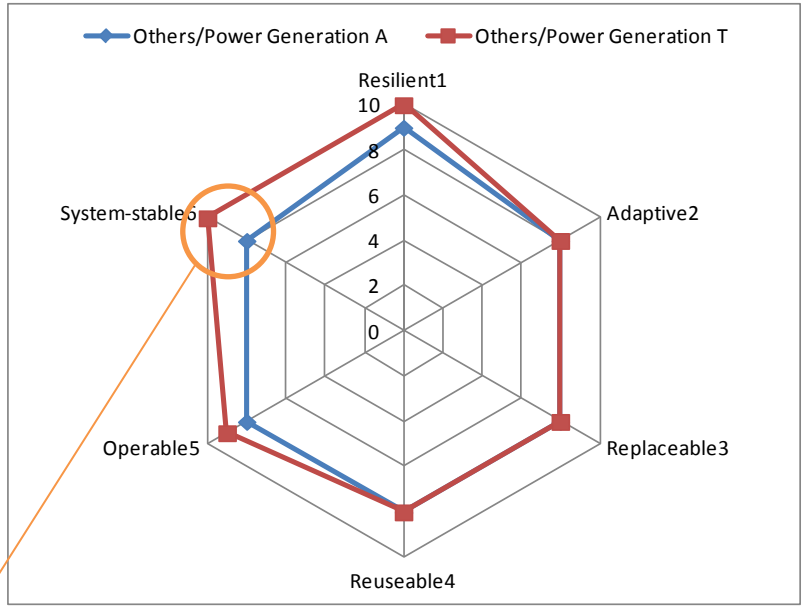
- Overall view of futureproofing (assets vs total futureproofing scores i.e. sum of weighted scores against multi-criteria)
- A – scores for actual futureproofing assessment
- T – scores for futureproofing targets

Results of futureproofing assessment of LWwTW

Primary Settlement – Pumps - one of the biggest futureproofing gaps



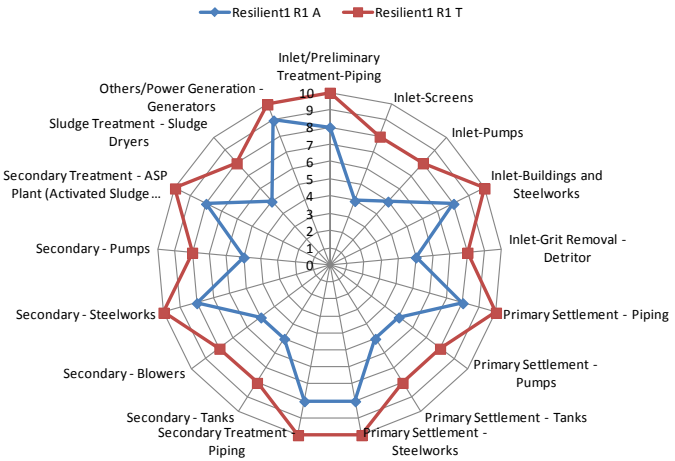
Others/Power Generation - the smallest futureproofing gap

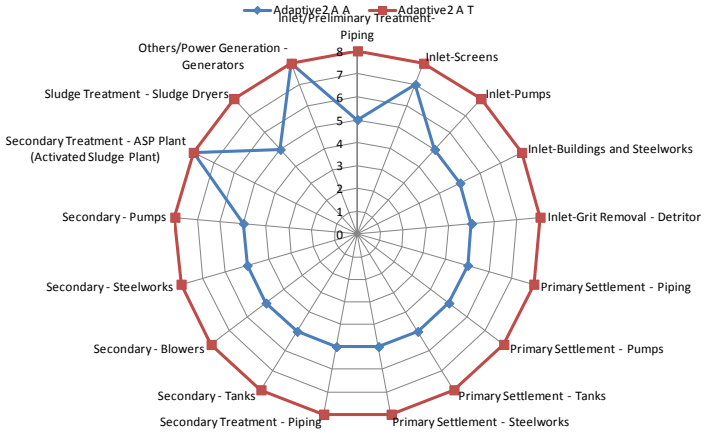


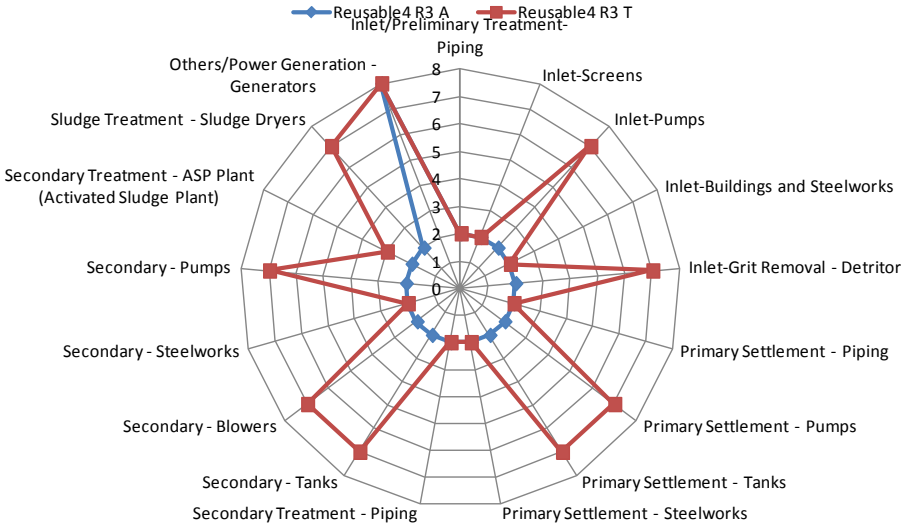
The biggest futureproofing gap

- 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

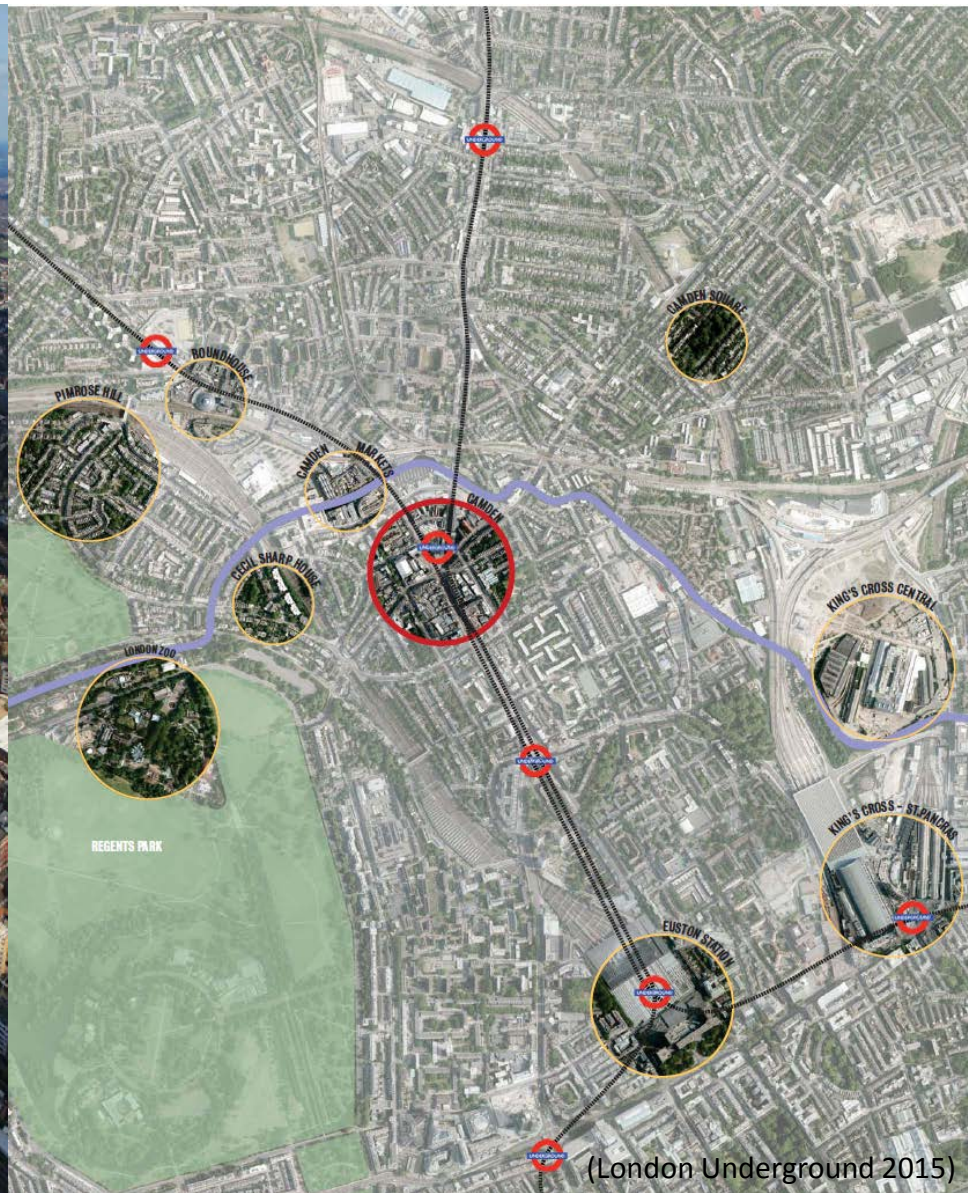






- Criteria views of futureproofing (futureproofing scores against multi-criteria vs assets)
- A – scores for actual futureproofing assessment
- T – scores for futureproofing targets

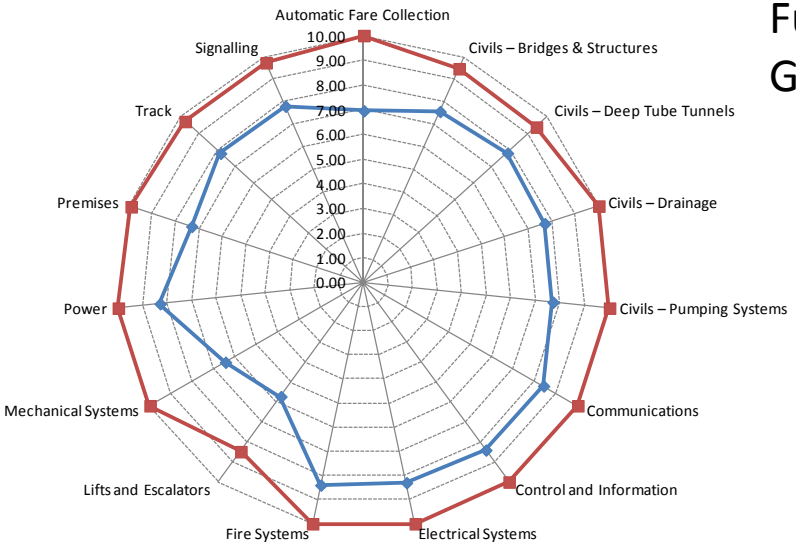
London Underground Camden Town Station – Futureproofing assessment case study 2



(London Underground 2015)

Results of futureproofing assessment of LU CT station

Innfrastructure Classification (1)	Futureproofing Criteria (2)																					W total	FPN (4)	
	Resilient1			Adaptive2			Replaceable3			Reusable4			Operable5			Information futureproof6			System-stable7					
	R1			A			R2			R3			O			O			S					
Assets	W	A	T	W	A	T (3)	W	A	T	W	A	T	W	A	T	W	A	T	W	A	T		A	T
Automatic Fare Collection	0.30	6	10	0.03		10	0.03	6	10	0.03	6	10	0.30	8	10	0.03	8	10	0.30	7	10	1.00	6.95	10.00
Civils – Bridges & Structures	0.30	7	10	0.03	2	2	0.03	1	2	0.03	5	5	0.30	8	10	0.03	7	10	0.30	9	10	1.00	7.58	9.48
Civils – Deep Tube Tunnels	0.30	8	10	0.03	2	2	0.03	1	1	0.03	3	3	0.30	8	10	0.03	7	10	0.30	9	10	1.00	7.83	9.40
Civils – Drainage	0.30	8	10	0.03	8	10	0.03	8	10	0.03	8	10	0.30	7	10	0.03	8	10	0.30	8	10	1.00	7.70	10.00
Civils – Pumping Systems	0.30	8	10	0.03	8	10	0.03	8	10	0.03	8	10	0.30	7	10	0.03	8	10	0.30	8	10	1.00	7.70	10.00
Communications	0.30	8	10	0.03	9	10	0.03	9	10	0.03	9	10	0.30	9	10	0.03	9	10	0.30	8	10	1.00	8.40	10.00
Control and Information	0.30	8	10	0.03	9	10	0.03	9	10	0.03	9	10	0.30	9	10	0.03	9	10	0.30	8	10	1.00	8.40	10.00
Electrical Systems	0.30	7	10	0.03	9	10	0.03	7	10	0.03	8	10	0.30	9	10	0.03	8	10	0.30	9	10	1.00	8.30	10.00
Fire Systems	0.30	8	10	0.03	9	10	0.03	9	10	0.03	9	10	0.30	9	10	0.03	9	10	0.30	8	10	1.00	8.40	10.00
Lifts and Escalators	0.20	8	10	0.04	2	3	0.10	2	5	0.06	4	5	0.16	7	9	0.14	7	8	0.30	5	10	1.00	5.72	8.48
Mechanical Systems	0.30	5	10	0.03	7	10	0.03	8	10	0.03	8	10	0.30	7	10	0.03	8	10	0.30	7	10	1.00	6.48	10.00
Power	0.30	7	10	0.03	9	10	0.03	7	10	0.03	8	10	0.30	9	10	0.03	8	10	0.30	9	10	1.00	8.30	10.00
Premises	0.30	7	10	0.03	8	10	0.04	8	10	0.01	1	1	0.30	6	10	0.03	8	10	0.30	9	10	1.00	7.33	9.91
Track	0.30	8	10	0.03	2	2	0.04	8	10	0.01	4	4	0.30	8	10	0.03	8	10	0.30	8	10	1.00	7.81	9.74
Signalling	0.30	8	10	0.03	2	2	0.04	8	10	0.01	4	4	0.30	8	10	0.03	8	10	0.30	8	10	1.00	7.81	9.74



Futureproofing Gap Analysis (5)

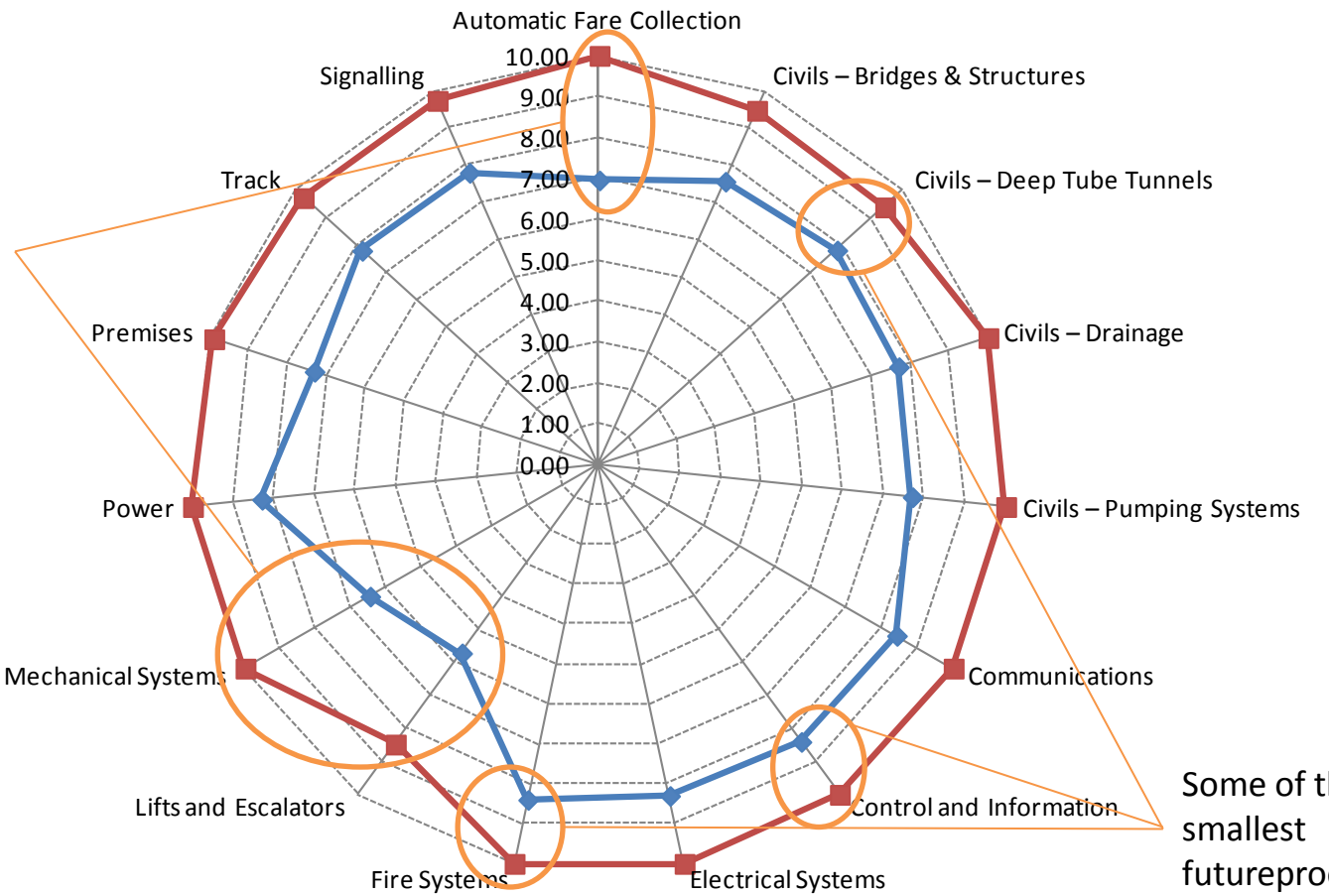
W – Weighted
A – Actual (1-10)
T – Target (1-10)

1 (least futureproof)
10 (most futureproof)

Gap = Weighted Target – Weighted Actual

Results of futureproofing assessment of LU CT station

Some of the biggest futureproofing gaps



W – Weighted
A – Actual (1-10)
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1 (least futureproof)
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Gap = Weighted Target – Weighted Actual

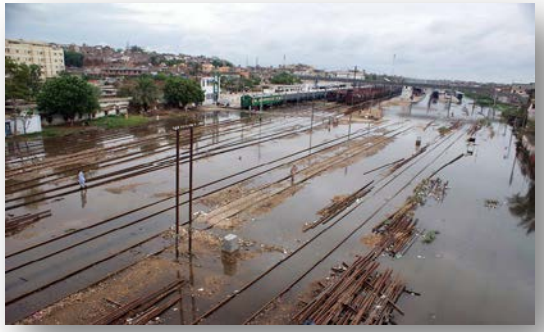
Some of the smallest futureproofing gaps

- 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 dash board for futrureproofing 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

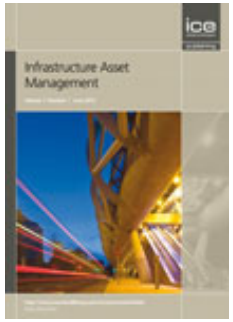
Impact

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).

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

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

Article on infrastructure futureproofing (published 6/2015).



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

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

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

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