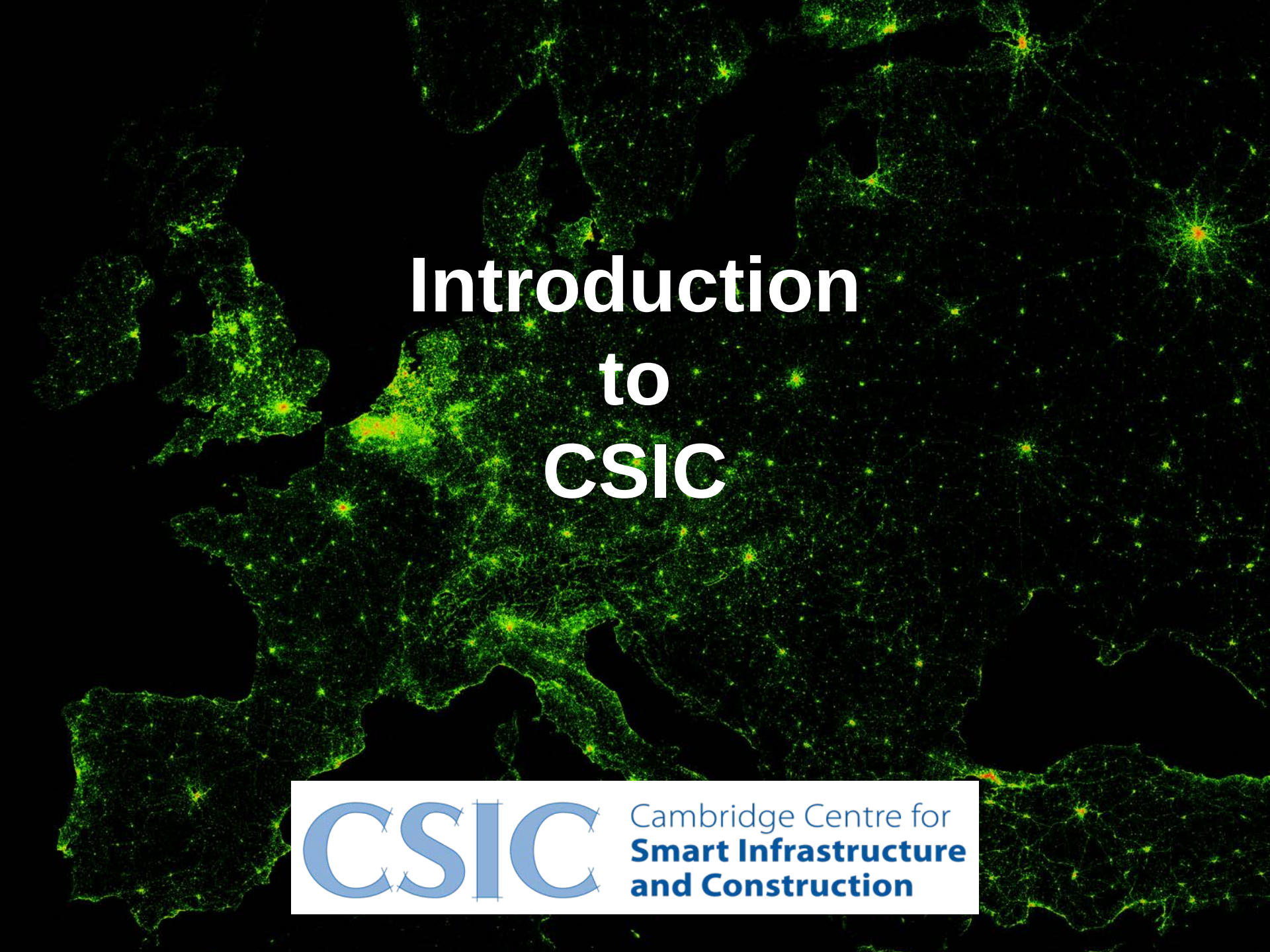

Introduction
to
CSIC
CSIC
Cambridge Centre for
Smart Infrastructure
and Construction

21st Century Infrastructure and Construction

- A high-quality national infrastructure is essential for supporting economic growth and productivity, attracting globally-mobile businesses, and for promoting social well-being

- Modern construction and infrastructure needs to be
  - Optimised in terms of efficiency, cost, low carbon footprint and service quality
  - Resilient, robust and adaptable to changing patterns
  - Innovative across all sectors – driven by business in partnership with government

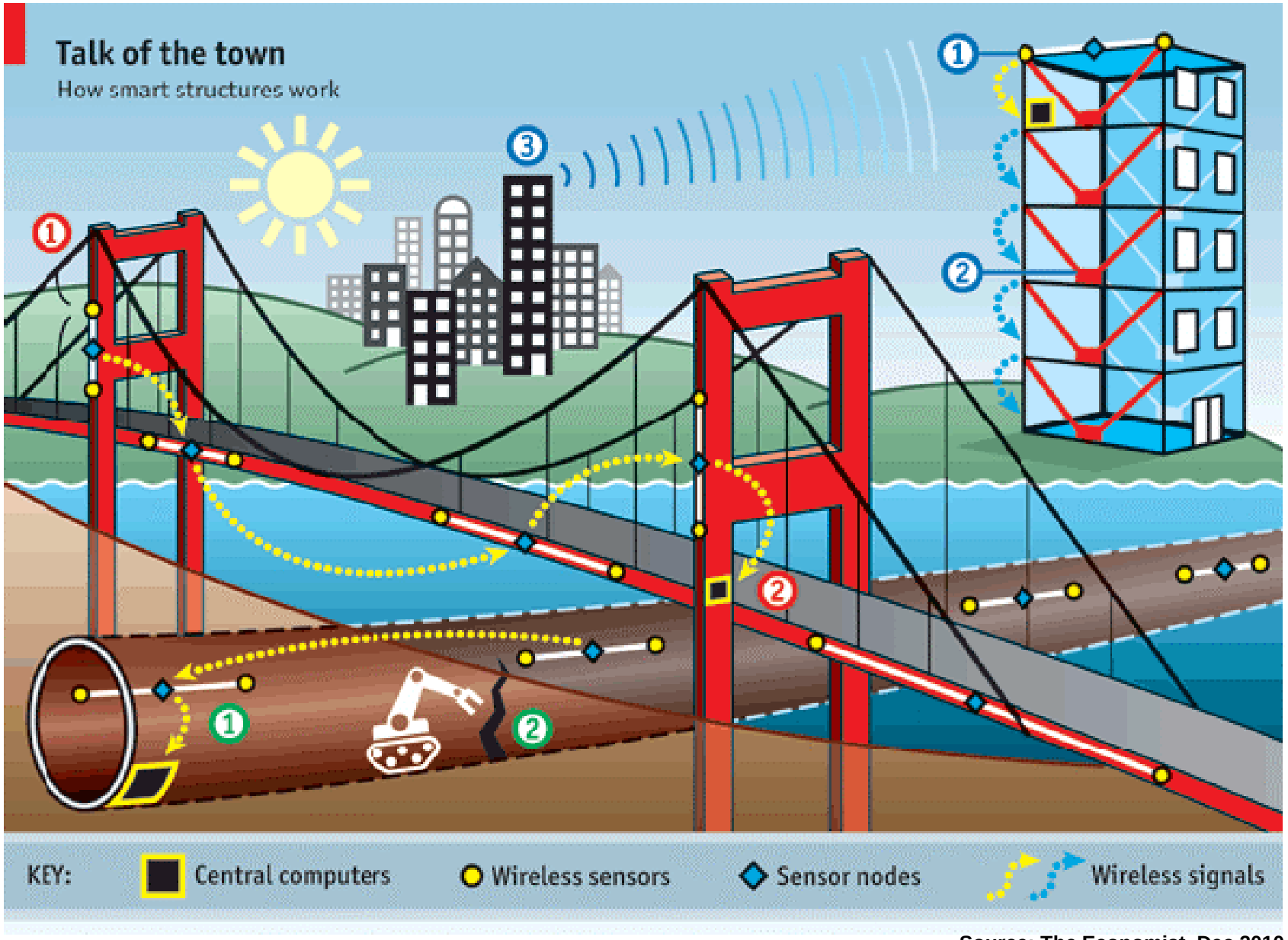
Vulnerability of our Infrastructure

Bridge collapse Minnesota 2007

Metro station collapse Singapore 2004

Flooded electricity sub-station UK 2007

Burst water main Boston 2003



Source: The Economist, Dec 2010

The Economist

Inside story

Superstructures

Engineering: Adding sensors and other devices to bridges, tunnels and buildings can turn them into "smart structures" capable of sensing and, in some cases, even responding to problems

Dec 9th 2010 | from PRINT EDITION

"If a car can be made smart enough to spot when the oil is low or a brake light has failed, why not do the same for bridges, tunnels and buildings?"

Recent developments in sensor technologies provide major new opportunities for ensuring resilient infrastructure

Cambridge Centre for Smart Infrastructure and Construction

An Innovation and Knowledge Centre
Funded by EPSRC and Innovate UK

Mission:

"Transform the future of infrastructure and construction through smarter information"

Multidisciplinary Innovation and Knowledge Centre translating research into practice in infrastructure and construction

Current CSIC partners

Infrastructure Clients (Owners and Operators)

Consultants, contractors and asset managers

Technology & information supply chain

Knowledge partners

EPSRC
Pioneering research and skills

Innovate UK
Technology Strategy Board

What is ‘smart infrastructure’?

‘Smart infrastructure’ has the ability to influence and direct its own use, maintenance and support by responding intelligently to changes in its environment.

The above definition has been developed by the Construction Leadership Council from Smart infrastructure: the future, The Royal Academy of Engineering & Cambridge Centre for Smart Infrastructure and Construction

In construction coordination and management

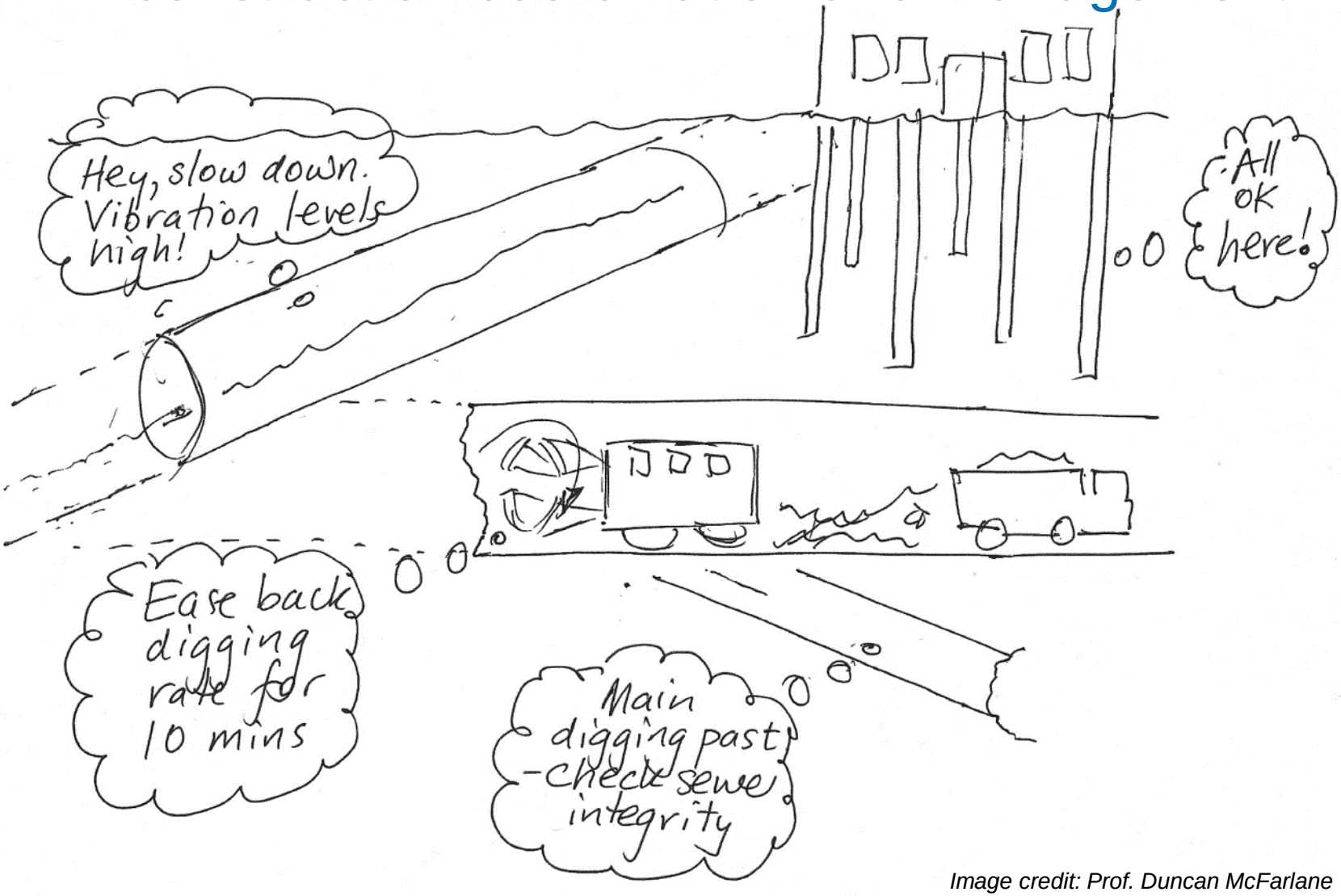


Image credit: Prof. Duncan McFarlane

In adaptive operations and condition based asset management

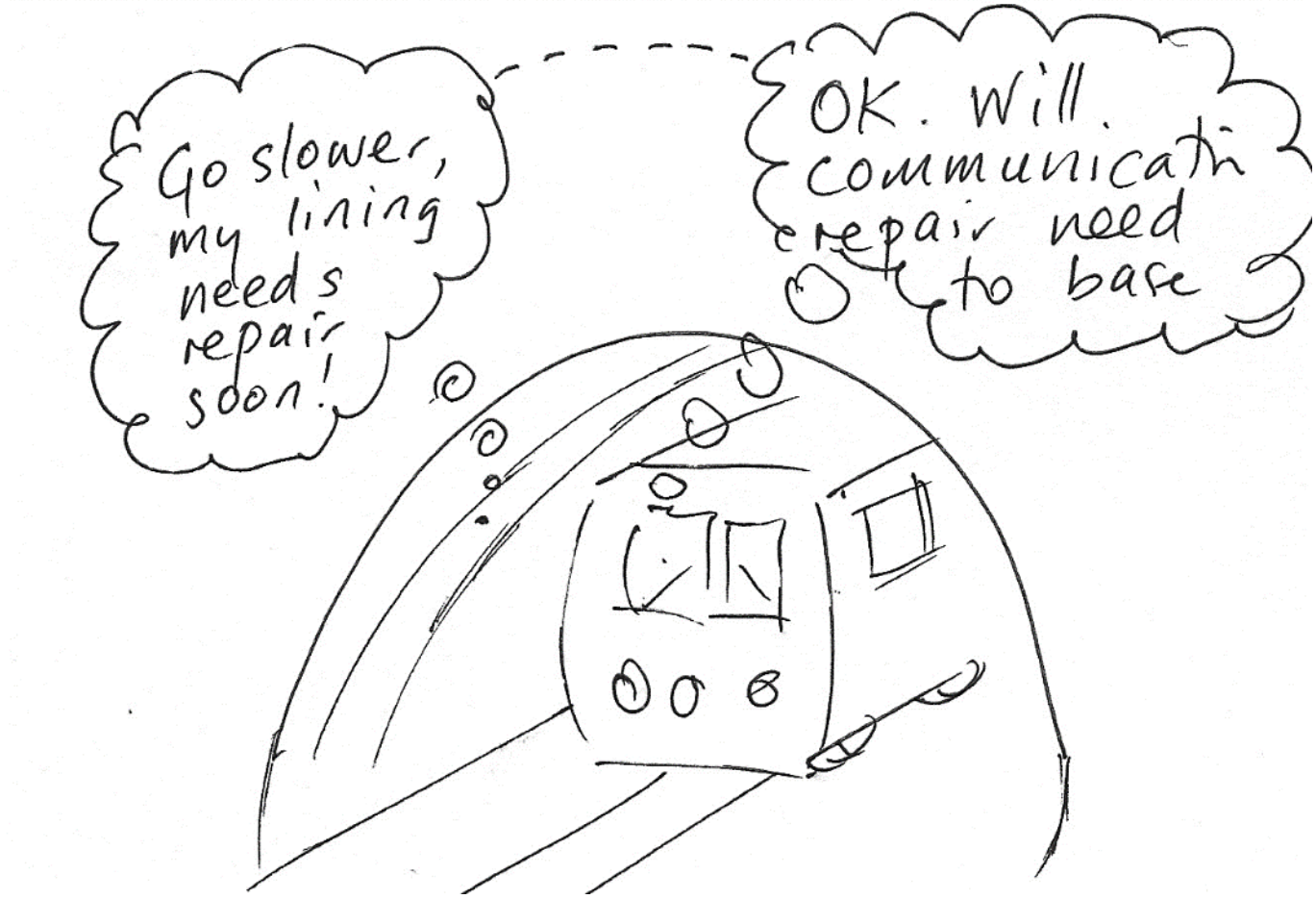
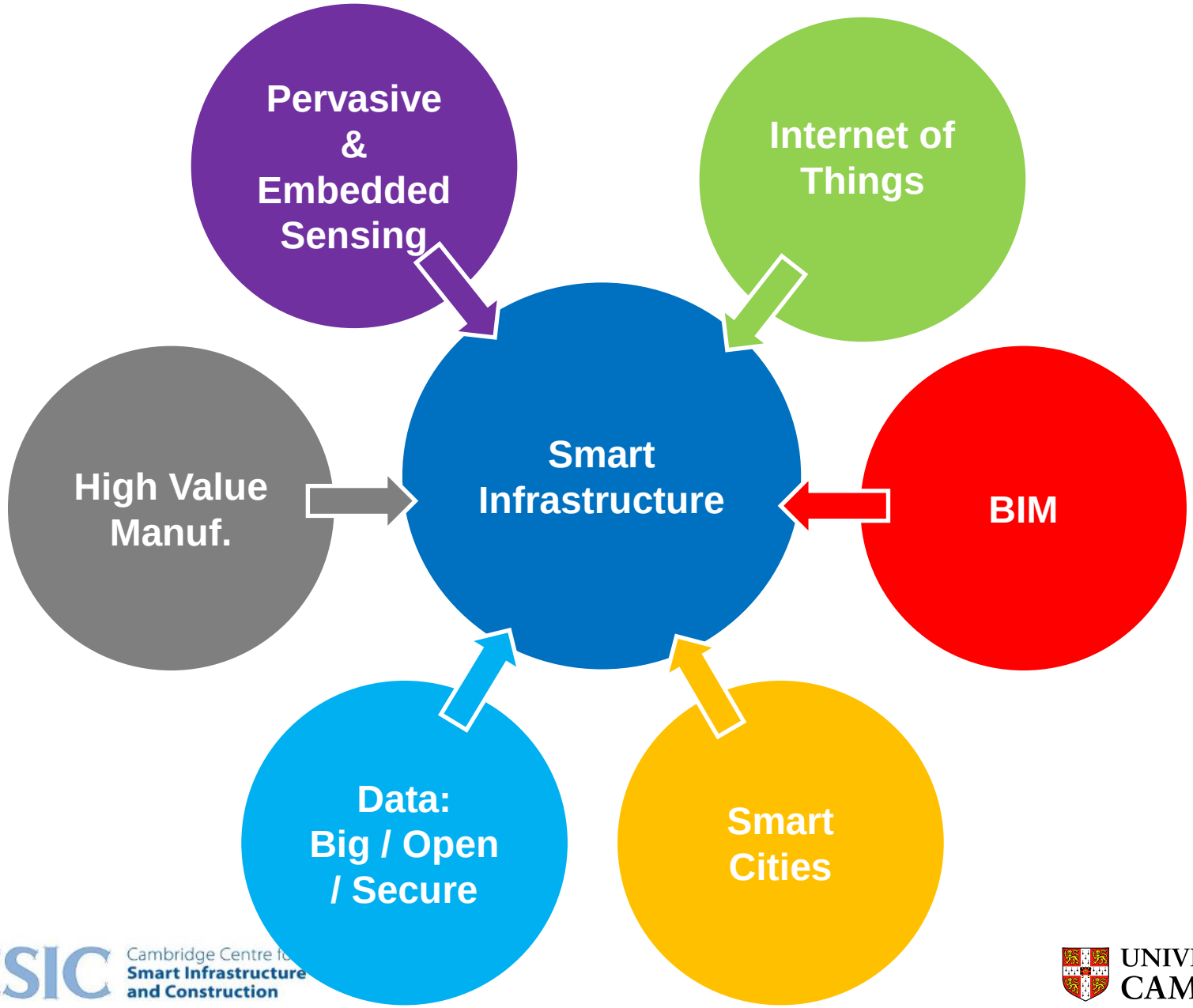
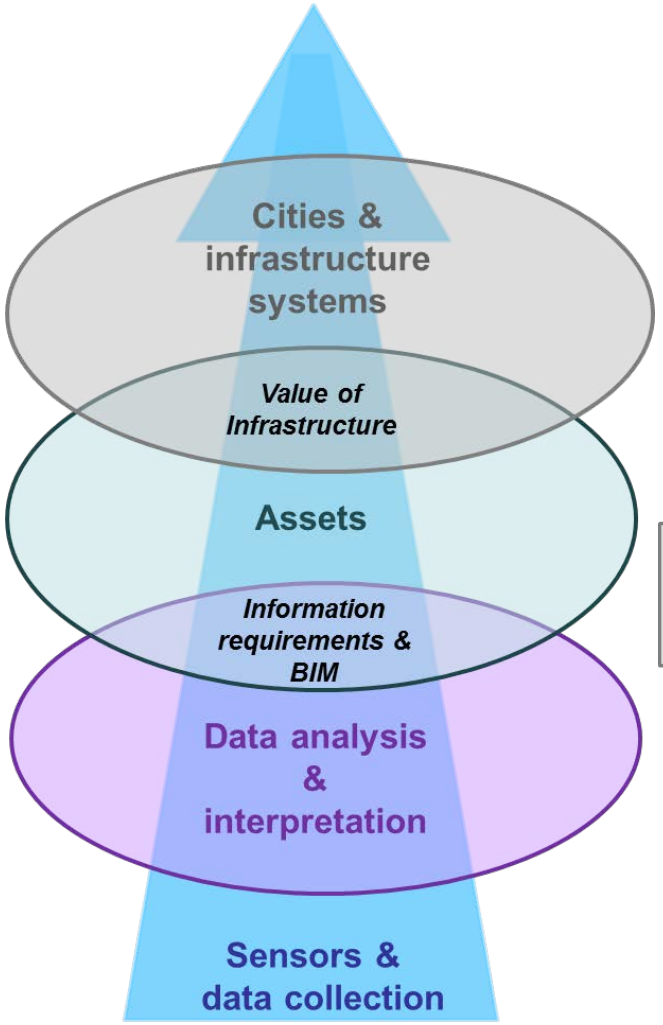


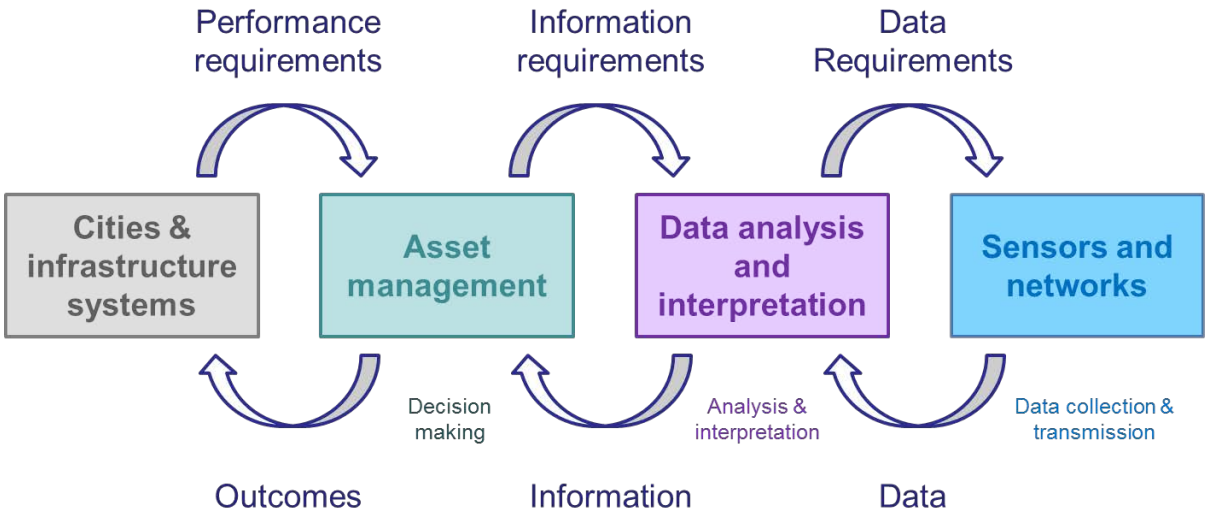
Image credit: Prof. Duncan McFarlane

Smart Infrastructure ….. Not an isolated subject!



Four scales of challenge





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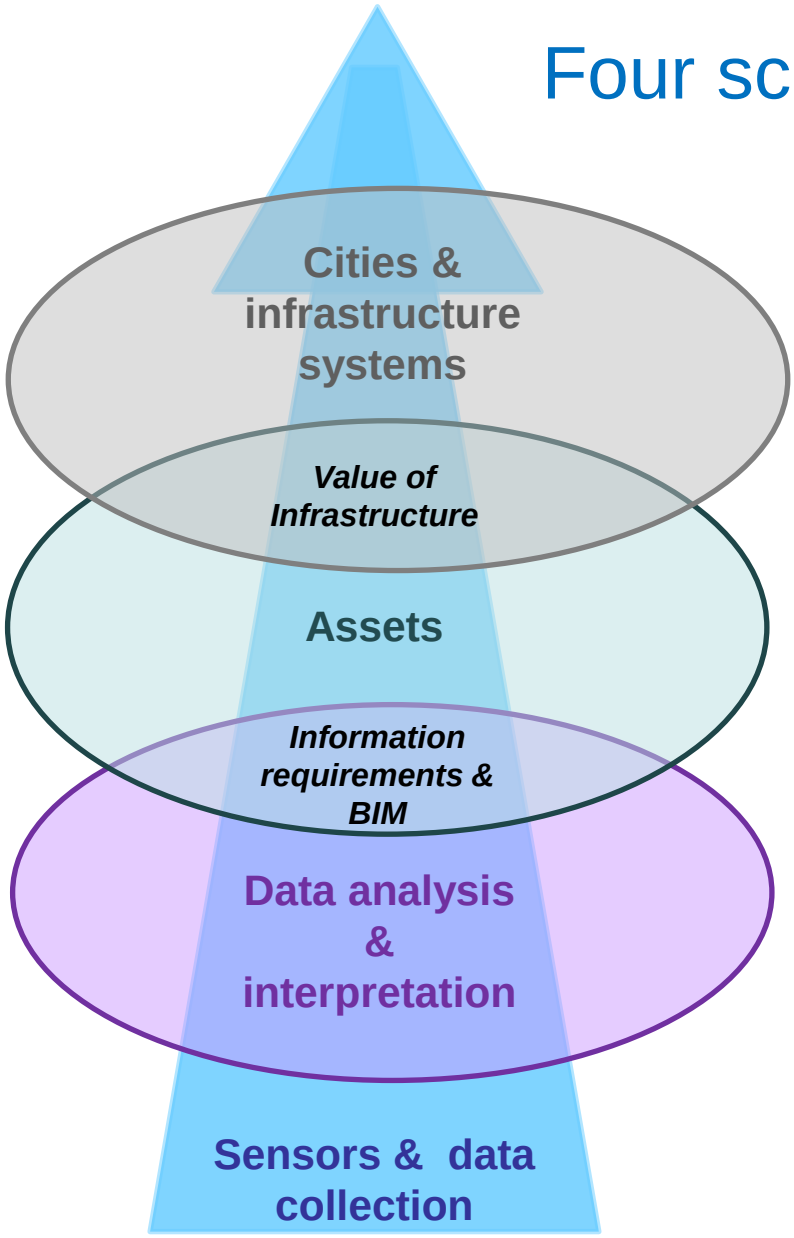
Four scales of challenge



CITY-SCALE SYSTEM OF SYSTEMS

- *What economic value does our infrastructure create?*
- *How does our infrastructure best serve our communities?*
- *What form should our infrastructure take?*

LIFETIME VALUE OF INFRASTRUCTURE

- *How do we operate, manage & maintain our assets to deliver best whole life value?*
- *How do we futureproof our assets against changing requirements & against shocks?*
- *What decisions? Supported b what information?*

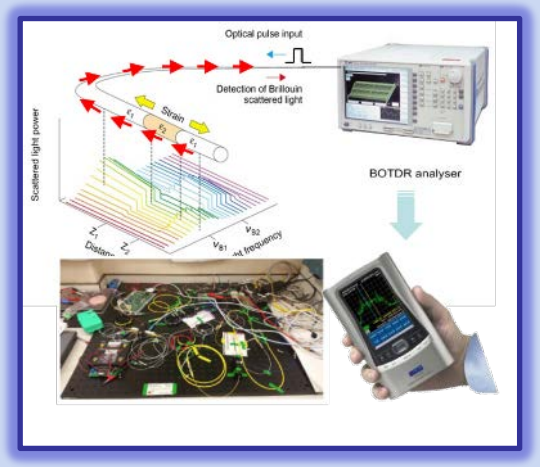
EFFICIENT ANALYSIS AND INTERPRETATION IN REAL TIME

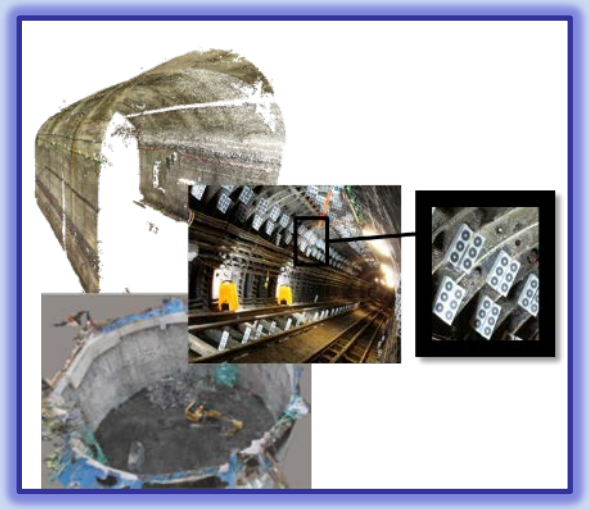
- *How do we best design, construct & monitor our structures to deliver the performance we need?*
- *What data do we need to do this, & how do we interpret it?*

ROBUST SENSOR SYSTEMS

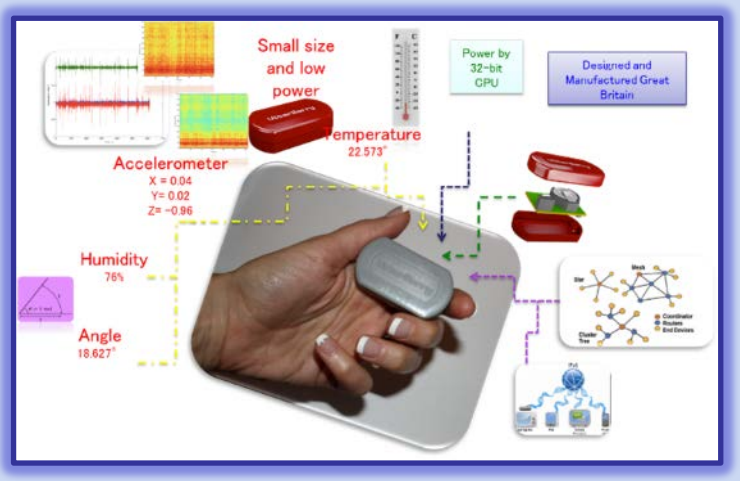
- *What sensors do we need?*
- *How can we make them robust?*
- *Reliable, robust systems for data collection*
- *Standards to enable interoperability*

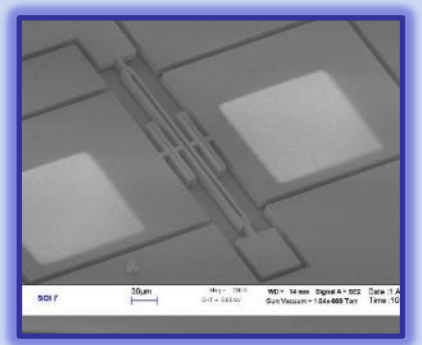
Sensors and Data Collection





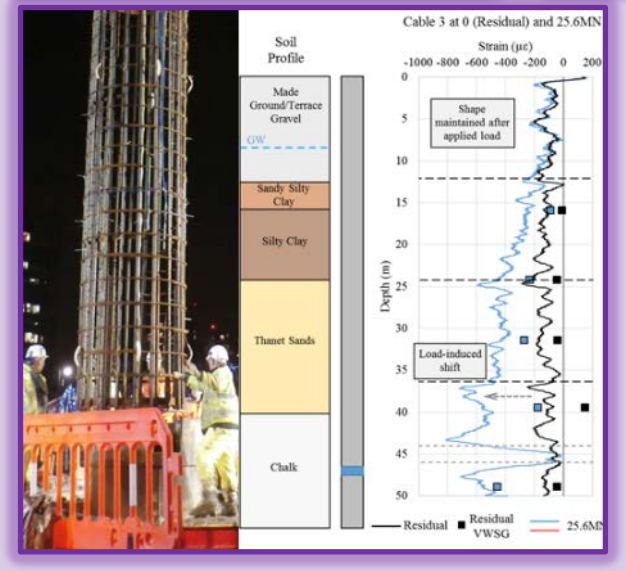
- *FO sensing*
- *FO analyser*
- *Computer vision – change detection, BIM*
- *Robotics*
- *Low power wireless sensors*
- *Low power WSN*
- *MEMS sensors*
- *Energy Harvesting*

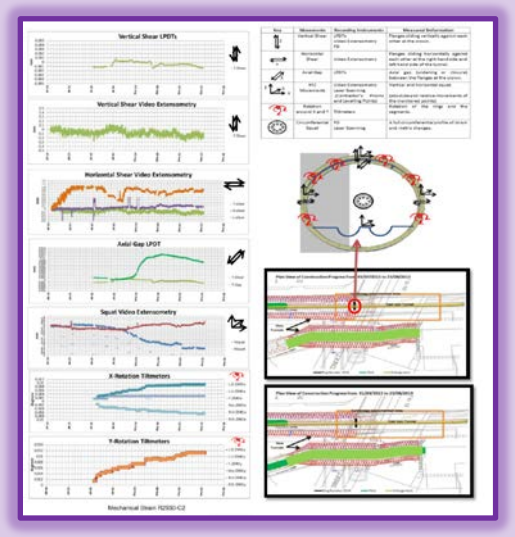


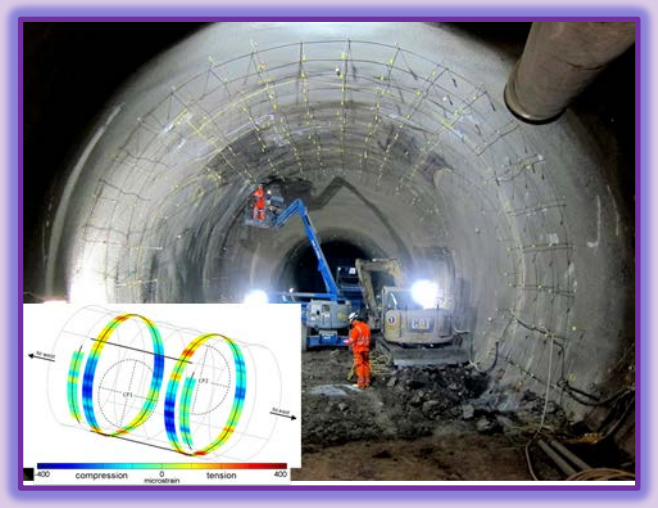


Data analysis & interpretation

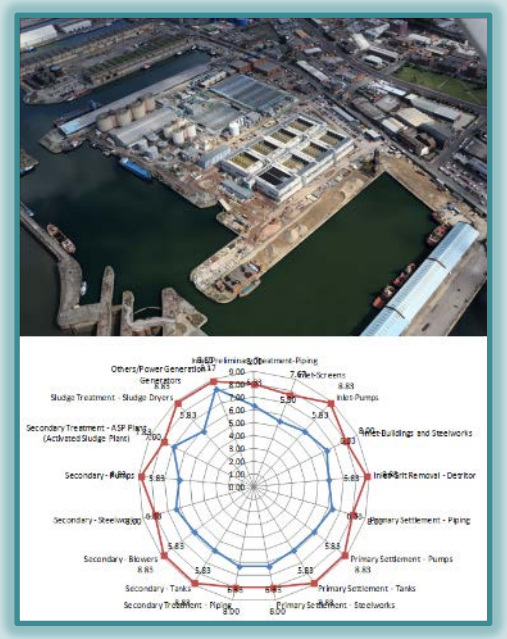
- *Data analysis tools*
- *Demonstration projects*
- *London Bridge Station demonstrator*
- *Crossrail*
- *Staffordshire bridges*
- *Piling monitoring and analysis*

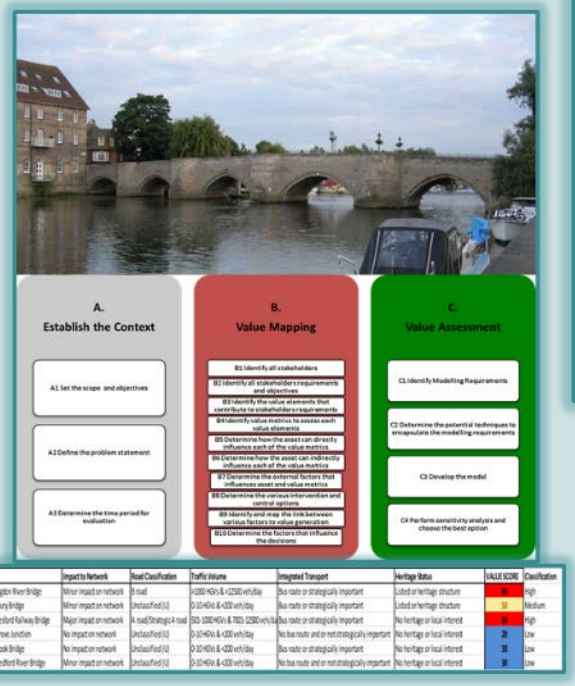




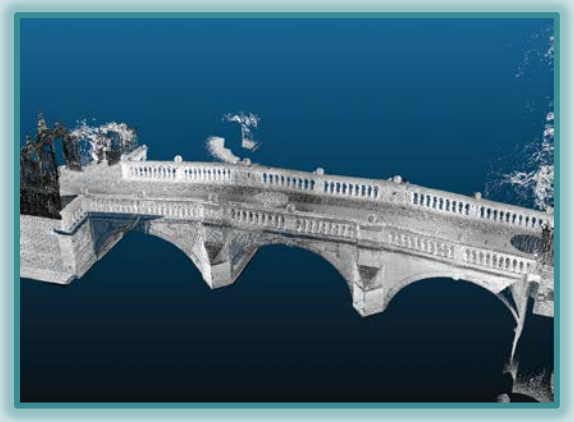


Asset Management





Bridge	Impact to Network	Road Classification	Traffic Volume	Integrated Transport	Heritage Status	VALUE SCORE	Classification
Huntingdon River Bridge	Minor impact on network	B road	>1000 HGVs & >12500 veh/day	Bus route or strategically important	Listed or heritage structure	65	High
Alconbury Bridge	Minor impact on network	Unclassified (U)	0-10 HGVs & <200 veh/day	Bus route or strategically important	Listed or heritage structure	53	Medium
Whittlesford Railway Bridge	Major impact on network	A road/Strategic A road	501-1000 HGVs & 7001-12500 veh/day	Bus route or strategically important	No heritage or local interest	65	High
Spirit Drove Junction	No impact on network	Unclassified (U)	0-10 HGVs & <200 veh/day	No bus route and or not strategically important	No heritage or local interest	28	Low
Willbrook Bridge	No impact on network	Unclassified (U)	0-10 HGVs & <200 veh/day	Bus route or strategically important	No heritage or local interest	36	Low
New Bedford River Bridge	Minor impact on network	Unclassified (U)	0-10 HGVs & <200 veh/day	No bus route and or not strategically important	No heritage or local interest	36	Low



- *Whole life value-based decision making*
- *Information requirements and risks*
- *Information futureproofing*
- *Asset futureproofing*
- *BIM for structural health monitoring*
- *3D digital model creation*

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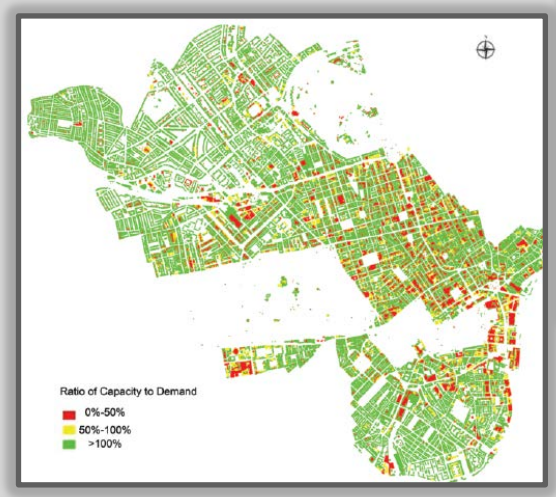
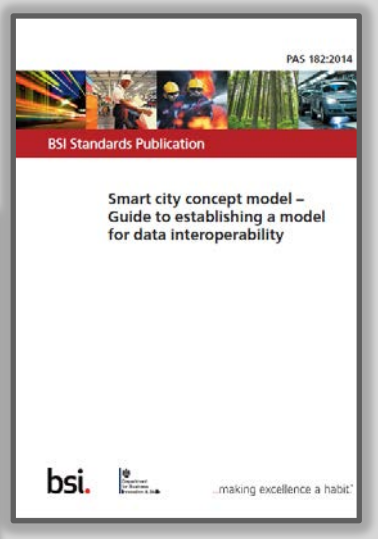
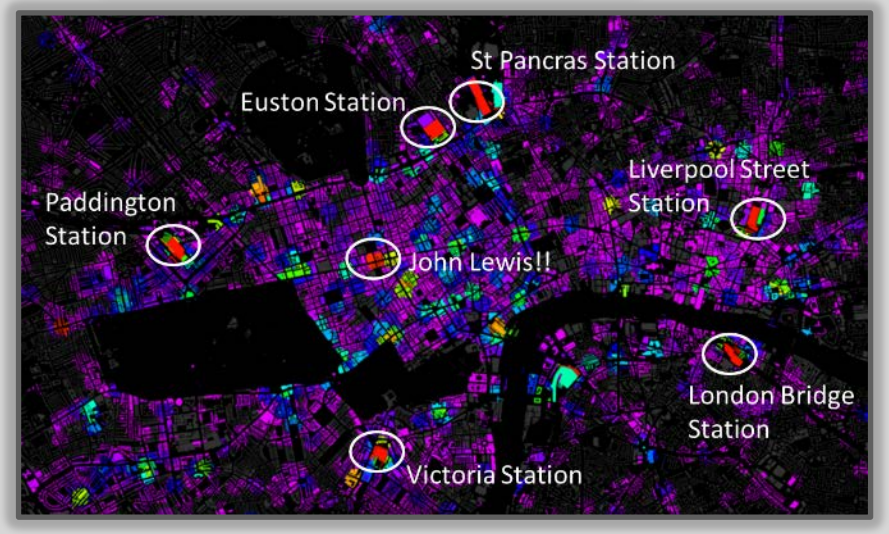
Cities and Infrastructure Systems



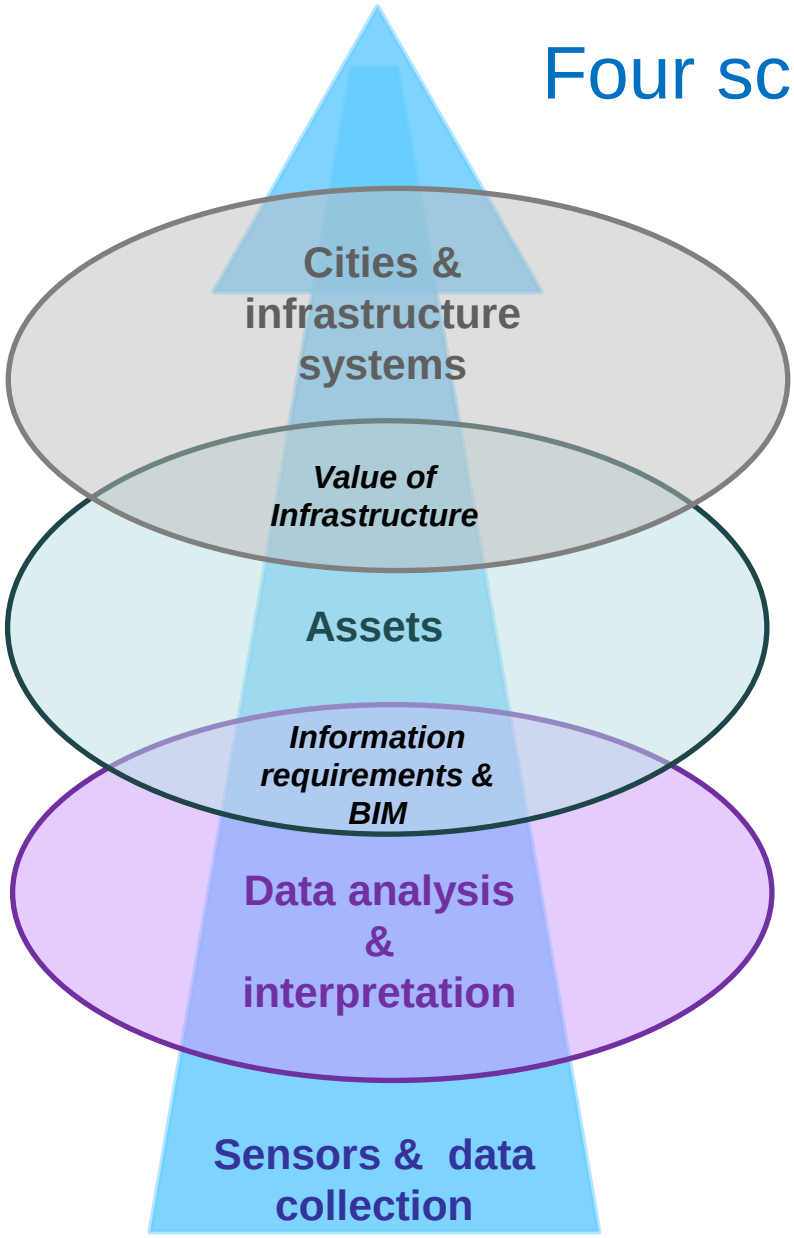


- *Smart city standards (with BSI)*
- *Rail-led urban development*
- *Demand forecasting*
- *Adaptive zoning for transport investments*
- *Energy – ground source heat pump applications at city scale*
- *Real time pedestrian monitoring*



CSIC Phase 2

Four scales of challenge



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Future challenges to address - CSIC Phase 2

Remaining challenges to the delivery of smart infrastructure

A. Lack of integrated solutions for smart infrastructure

B. Limited industry appetite for innovation – reliability & safety concerns

C. Lack of a strong business case for smart infrastructure solutions

D. Lack of choice in the supply chain

CSIC Phase 2 - plan for delivery

A. Delivering integrated, innovative solutions

New innovations

- Sensors and data collection
- Data analysis and interpretation
- Asset management
- Cities and infrastructure systems

Integrated solutions

B. Building industry confidence

Demonstrating reliability and safety:

- Short term deployments
- Long term demonstration programmes

C. Articulating the business case

Working with industry and academia

- Model development
- Evidence gathering
- Case studies

D. Developing the supply chain

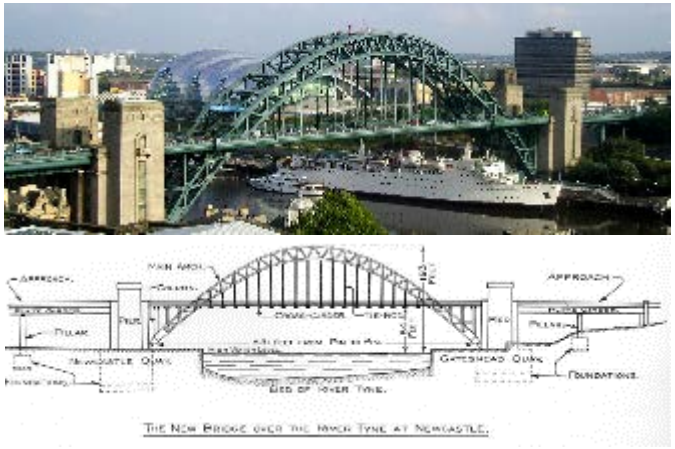
- Direct engagement
- Enabling activities
- Awareness raising
- Collaboration with industry partners

A. The value of an integrated smart approach

(1) Fibre Bragg in bridge deck - dynamic

(2) Wireless strain gauges

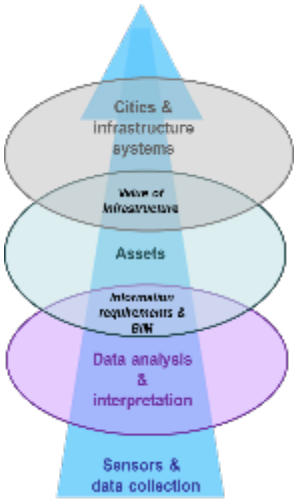
(3) Brillouin FOS in pier foundations



(6) Traffic monitoring and modelling

(5) Automated remote photogrammetry

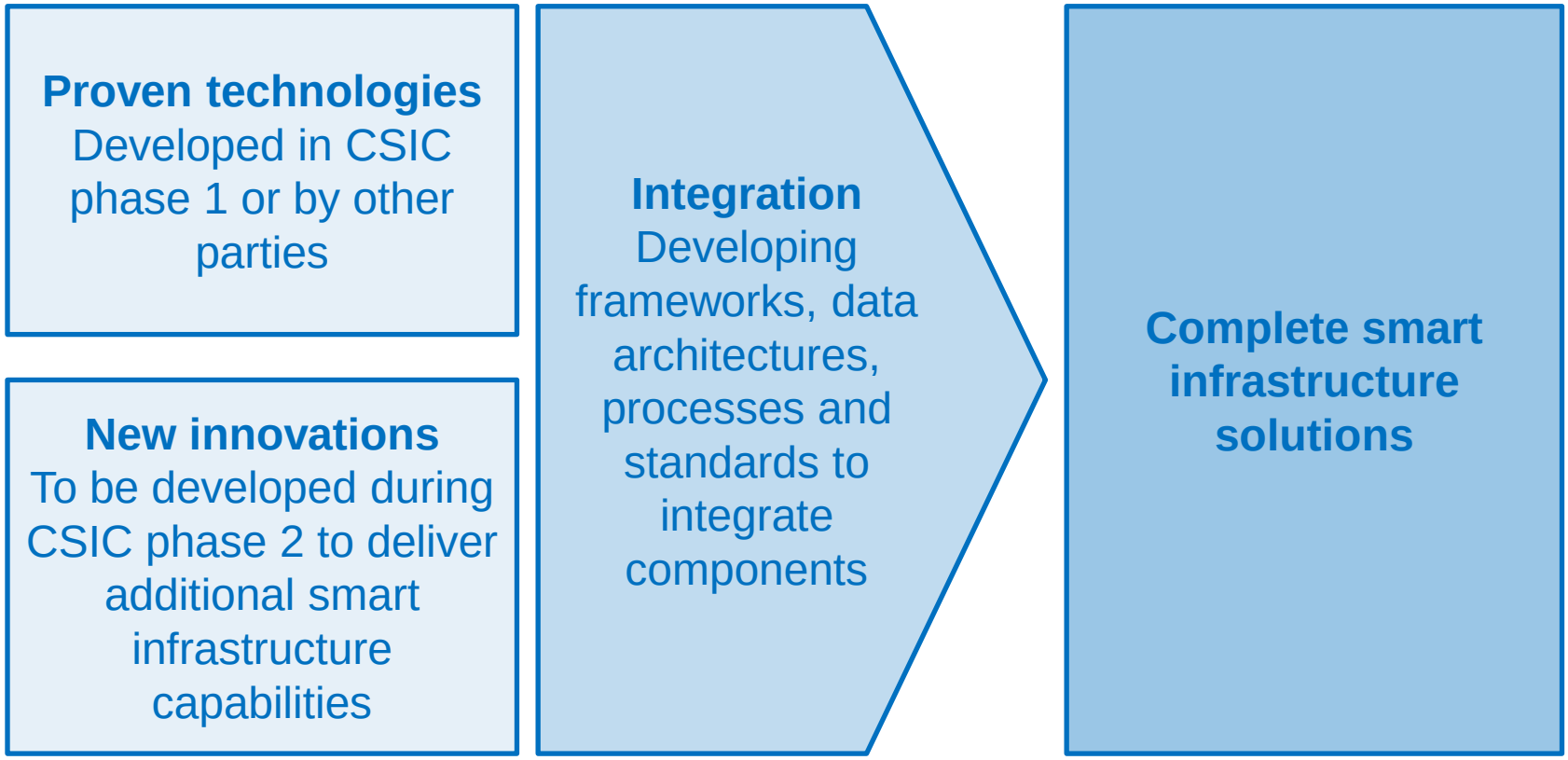
(4) As-built BIM model from digital imaging



Benefits:

- Sensor measurements inform design reducing cost of future bridges, and construction managing risk and safety
- BIM model created through digital imagery, combined with sensor measurements, inform asset management strategy
- Risk-based asset management reduces cost of maintenance and interruptions to operation
- Traffic monitoring and asset condition used to model traffic flows and inform future route choices

A. Developing innovative, integrated solutions



A.1 Developing further NEW innovations

(i) Sensors and data collection

- *Reliable long life time sensors (50 years or more)*
- *Robust sensing devices for extreme conditions (large deformation, high loading, etc.)*
- *Fast prototyping for civil sensing devices*
- *Mobile sensing, people sensing,*
- *Digital imaging: tomography, automated inspection, change detection*
- *Vehicle- and Robot-mounted monitoring systems*

(ii) Data analysis and interpretation

- *Smart cities, linked data and infrastructure monitoring*
- *Life cycle modelling & monitoring of infrastructure*
- *Monitoring and modelling of existing structures (masonry) subjected to new construction*
- *Disaster reconnaissance coupled with ultrafast structural modelling*
- *Understanding the performance of new construction technologies such as sprayed Concrete lining*
- *Remote slab track monitoring for high speed rail*

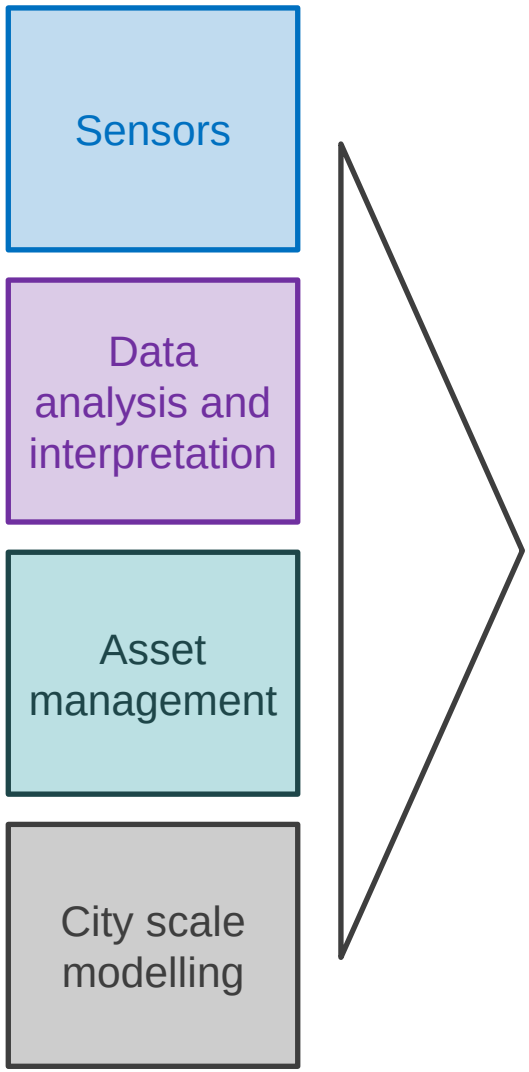
(iii) Asset Management

- *System-wide smart asset management*
- *Linking condition monitoring (sensor data) to Asset Management Decisions*
- *Extending whole-life value methodology to support asset management decisions*
- *Infrastructure Simulation Lab for whole life asset management decision making – linking to City-Scale*

(iv) Cities and infrastructure systems

- *Smart cities, linked data and infrastructure monitoring*
- *Understanding the complex urban infrastructure system of a city for evidence based policy making*
- *Coordinating multi-scale decision making in a city*
- *Interactive Simulation of Urban-Scale Built Environments*
- *Future Renewable Energy Infrastructure Options Analysis*
- *Retrofitting Urban Infrastructure: Analysis of re-use and synergistic energy systems*

A2. Delivering INTEGRATED solutions



- Developing linked data approaches & data analytics for sensor data from infrastructure and construction monitoring
- Linking condition monitoring data from sensors to asset management decisions
- Modelling and simulation to evaluate impact of asset management decisions on whole life value
- Modelling to enable coordinated multi-scale decision making in cities, based on sensor data
- Developing guidance and examples for coordinated data management using smart city standards (PAS182), asset management standards (ISO55000) and BIM data management standards (PAS1192)

Breakout Session 1
Prioritising Opportunities

	Understanding asset management	Making the right AM decisions	Effective management of asset information/technologies
Models and tools		• Long-term investment planning • Linking degradation to performance • Infrastructure performance simulation platform • Modeling risks before and after sensor deployment or change of AM strategy • Diverse asset portfolio management	• Hadoop-based asset info model
Integrated Solutions		• Integration of enterprise IS for real-time risk analysis • Integrating OM, IM, and AM decisions • Integrating data and physics-based deterioration models	• Solutions for futureproofing building foundation data • HW/SW for Mobile working • Integrating data from multiple data sources
Guidance	• AM Benefits • Idiot's guide to ISO 55000 • Integrating ISO 55000 with other quality management frameworks	• How to use sensory data for managing slow processes • Simplify risk management and risk-based DM for AM	• Generic whole life asset information requirements register • Generic asset information resources • Integrating BIM and digital technology with asset management • Horizon scanning and assessment of digital technologies
Methodologies	• Methodology to quantify AM Benefits (Maturity vs. Performance)	• WLC-based evaluation of D&B tenders • Incorporating sustainability • Very (100+ yr) long-term investment planning	• Economic data gathering and processing to reveal clear priorities for future (long term) action • Effective sensing strategy

Instructions

Challenges suggested – what should CSIC focus on?

First 10 mins:

1. Review the prepared lists (see also handouts)
2. Add any key elements that are missing

Then:

3. Vote using your 4 dots
   - **What should CSIC Phase 2 focus on?**
   - You can vote for more than one topic on a sheet
   - Please only vote for each topic ONCE

TEA BREAK

Breakout Session 2
Defining Opportunities

CSIC Cambridge Centre for Smart Infrastructure and Construction

Project title:		
Breakout Participants	What challenge(s) will the project address?	Why is it a challenge?
	What are the expected outcomes of the project?	What are the expected benefits to Industry?
Suggested next steps		

Instructions

- As a group, spend 5-10 minutes completing each box

Wrap up and next steps

www.centreforsmartinfrastructure.com

THANK YOU!

CSIC Cambridge Centre for Smart Infrastructure and Construction

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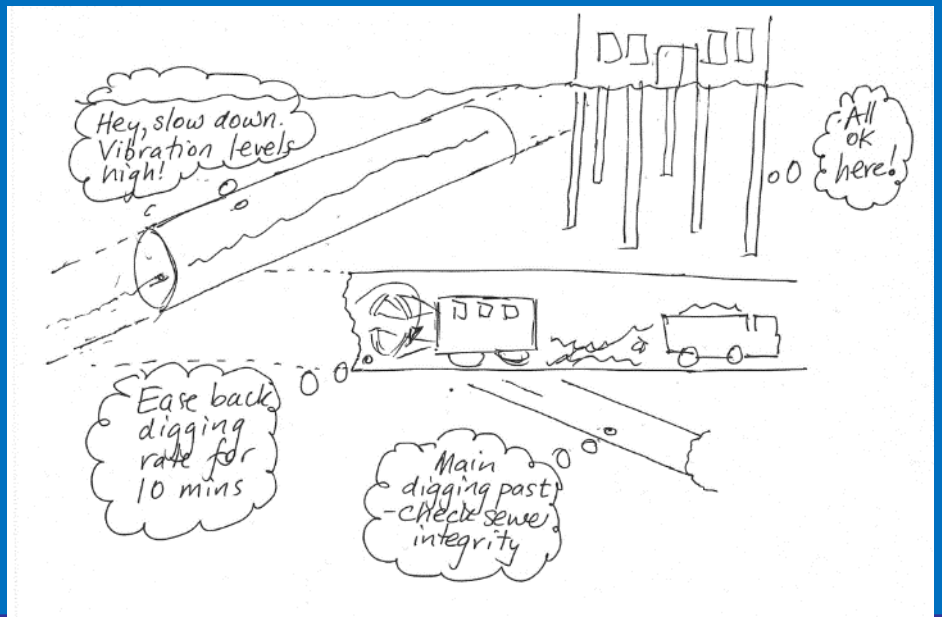
The future of smart infrastructure….

More assets, less money =>
new approach to infrastructural asset planning, design, construction & management

Assets as **value providers**
not cost generators



Asset management **information "provided" by asset** itself

Smart technologies embedded in infrastructure & the equipment it interacts with