UNIVERSITY OF CAMBRIDGE

CSIC Cambridge Centre for Smart Infrastructure & Construction

Smart infrastructure – getting more from our strategic assets

@CSIC-IKC

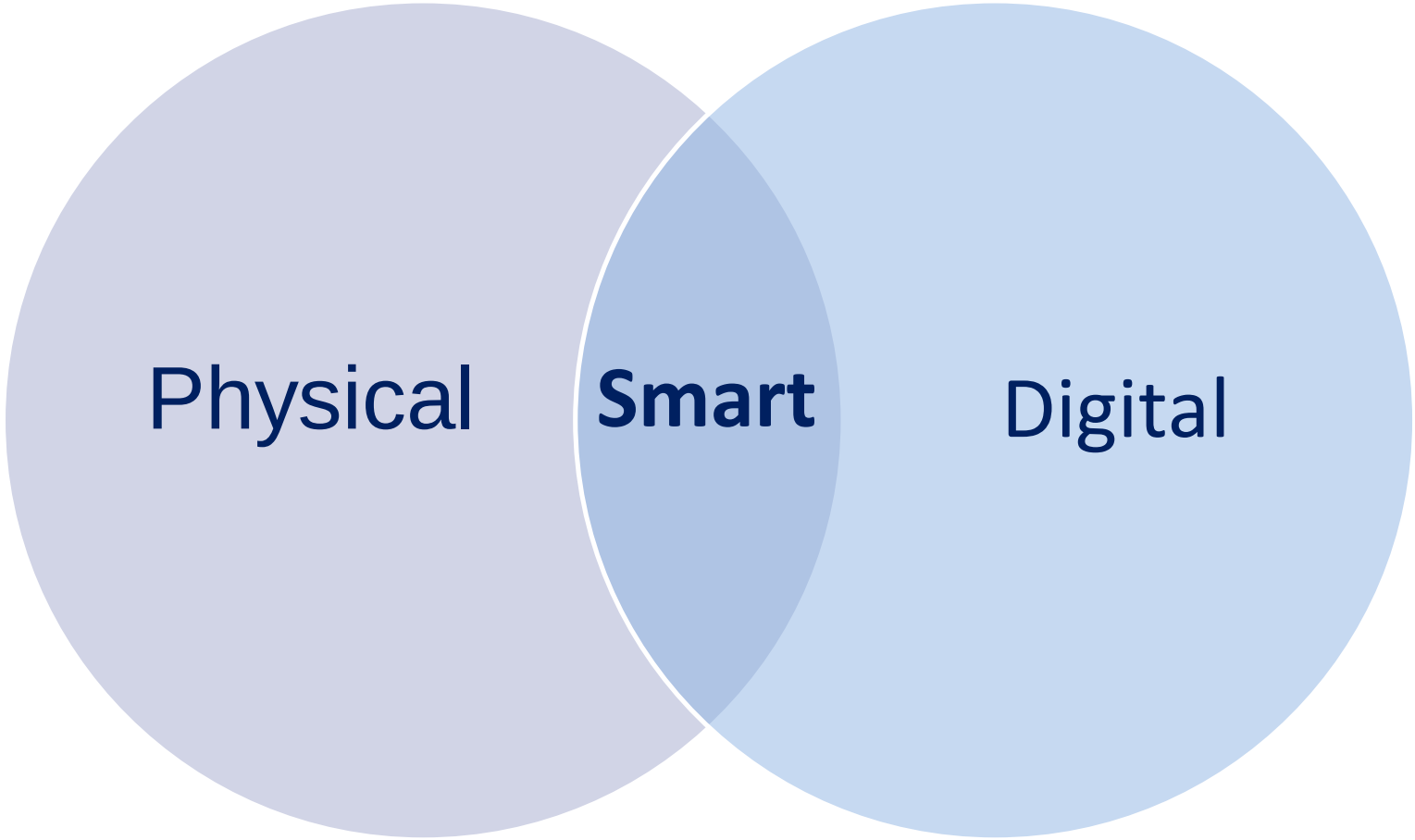
www.centreforsmartinfrastructure.com

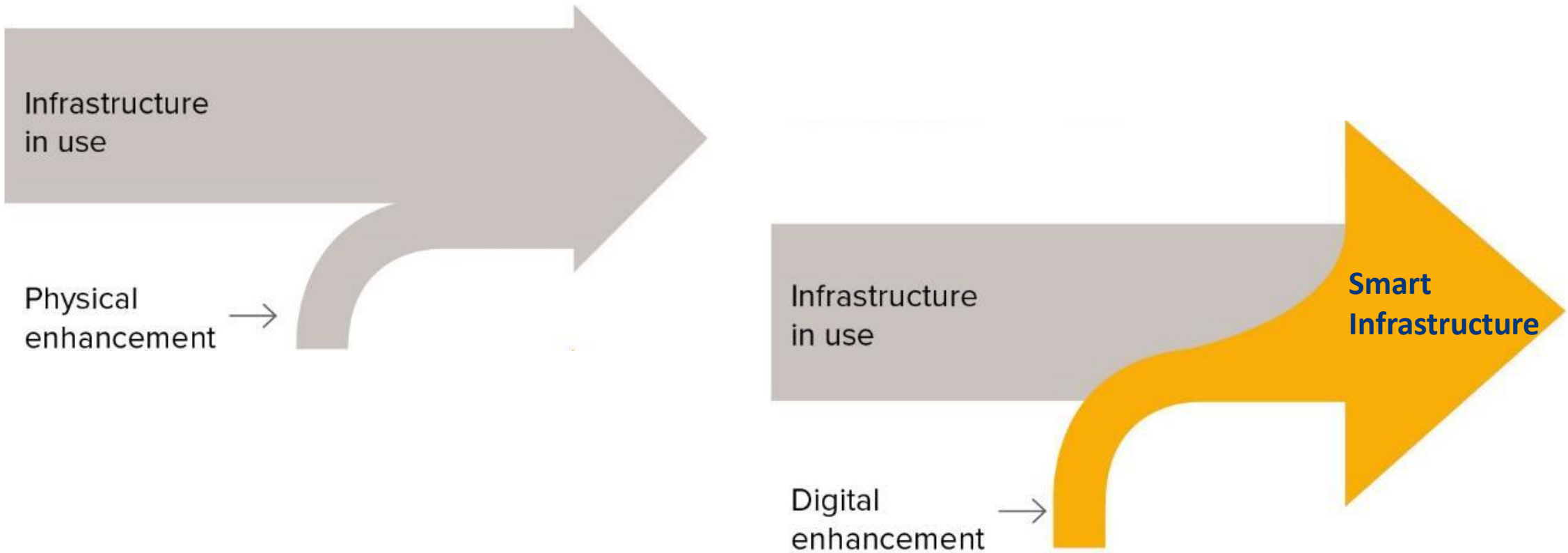
Innovate UK

EPSRC Engineering and Physical Sciences Research Council

Smart Infrastructure:

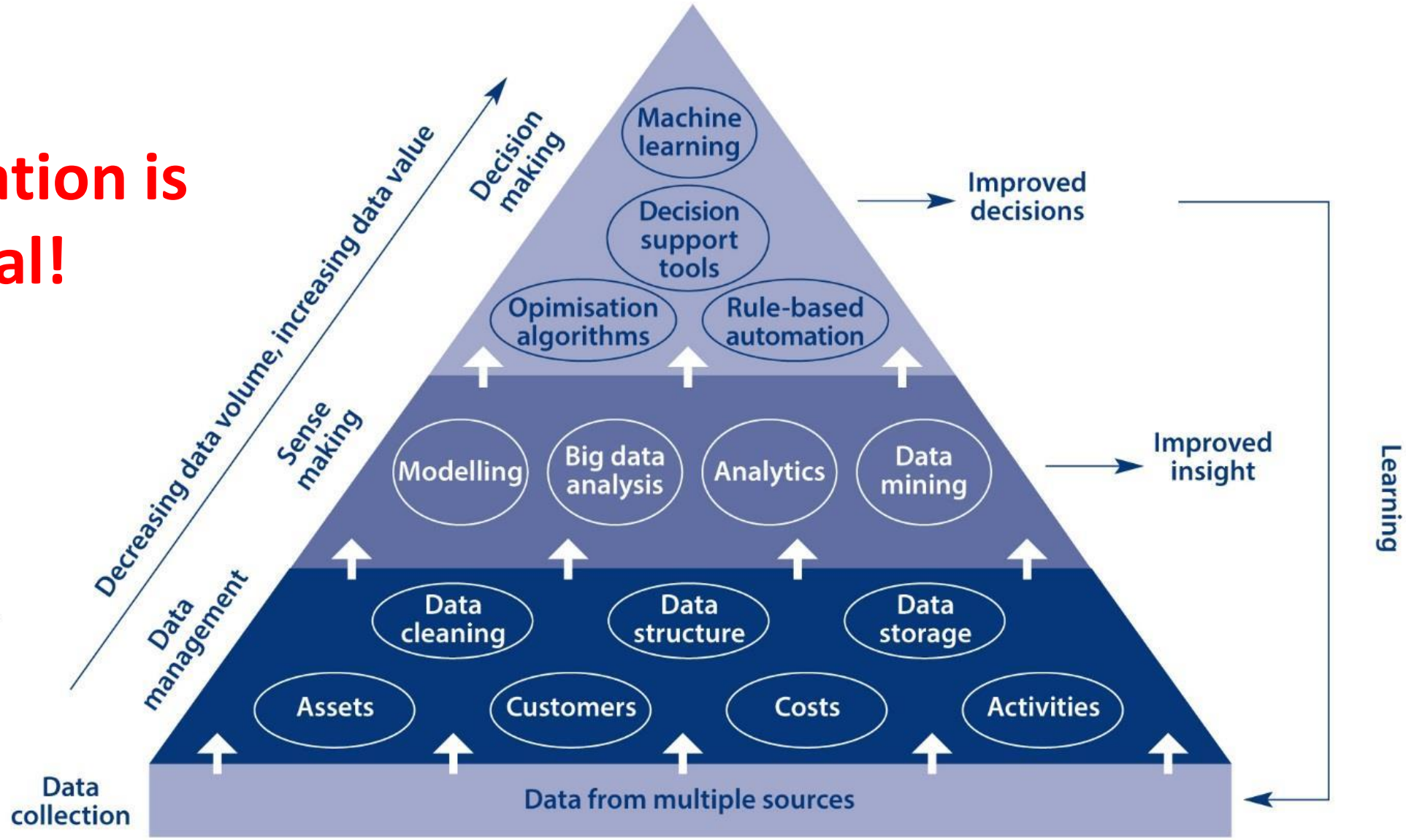
Better decisions faster and cheaper
for the benefit of the ultimate customer or user




Infrastructure
in use
Physical
enhancement
Infrastructure
in use
Digital
enhancement
Smart
Infrastructure

The value of data

Data curation is crucial!

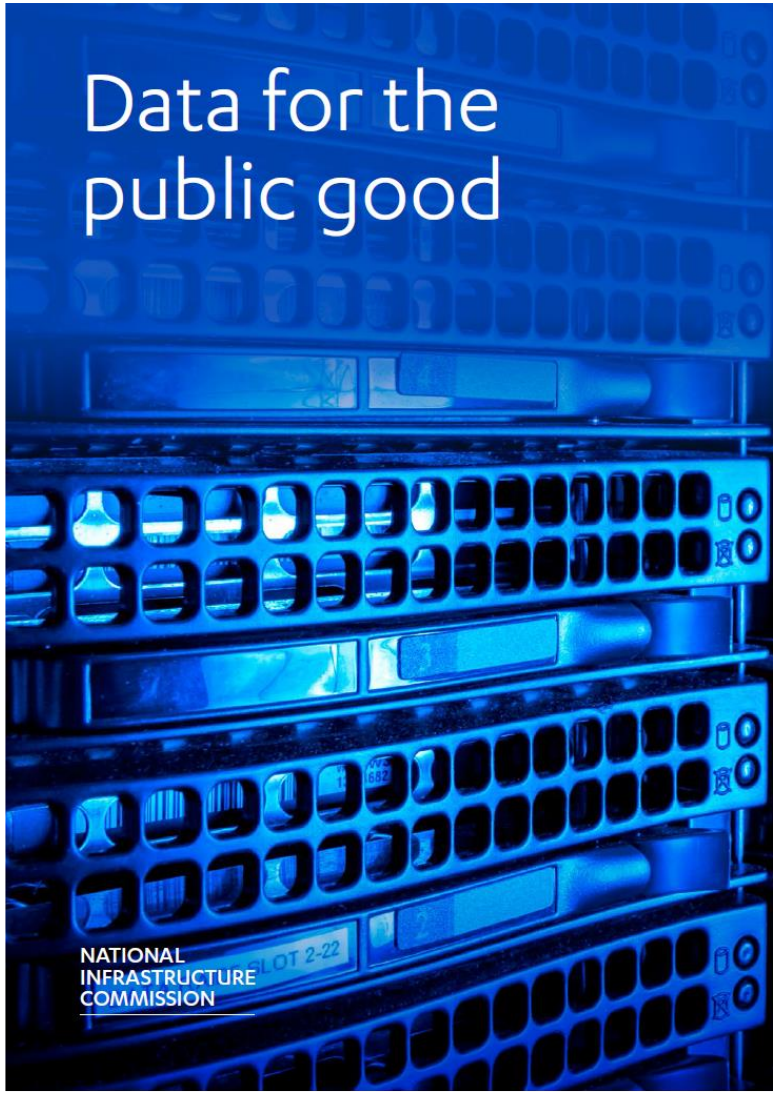


Data for the Public Good - NIC

- Identified key challenges around data in the UK economic infrastructures:
  - Lack of integration of data between infrastructure systems / silos
  - Failure to use data optimally to enable improved operation of infrastructure systems (data driven decision-making)

- Data as Infrastructure
  - Vastly increased quantities of data
  - New mechanisms to collate, manage and process - >
  - New opportunities for society to better utilise resources, solve problems and provide most social good

- Data Sharing in Infrastructure
  - Improve efficiency through better informed decisions
  - Better infrastructure planning
  - Improved resilience
  - Increased competition and innovation



There are many sources of data!

REMOTE SENSING

- Use of satellite data to monitor large-scale structural and ground movement
- Drone surveys
- Laser scanning
- Photogrammetry

AUTOMATED SENSING SYSTEMS

- Automated visual inspection
- Remote controlled boat for underwater surveying
- Mixed reality automated solutions for construction progress monitoring

SOCIAL MEDIA AND OTHER DATA SOURCES

- Geo-tagged social media data for assessing use of infrastructure and sentiment mapping
- Ticketing information
- Mobile phone GPS, wifi
- On-vehicle GPS, vehicle mounted sensors

EMBEDDED SENSING SYSTEMS

- Fibre optic strain sensors
- Fibre-optic geogrid systems
- Wireless sensors for earthworks monitoring

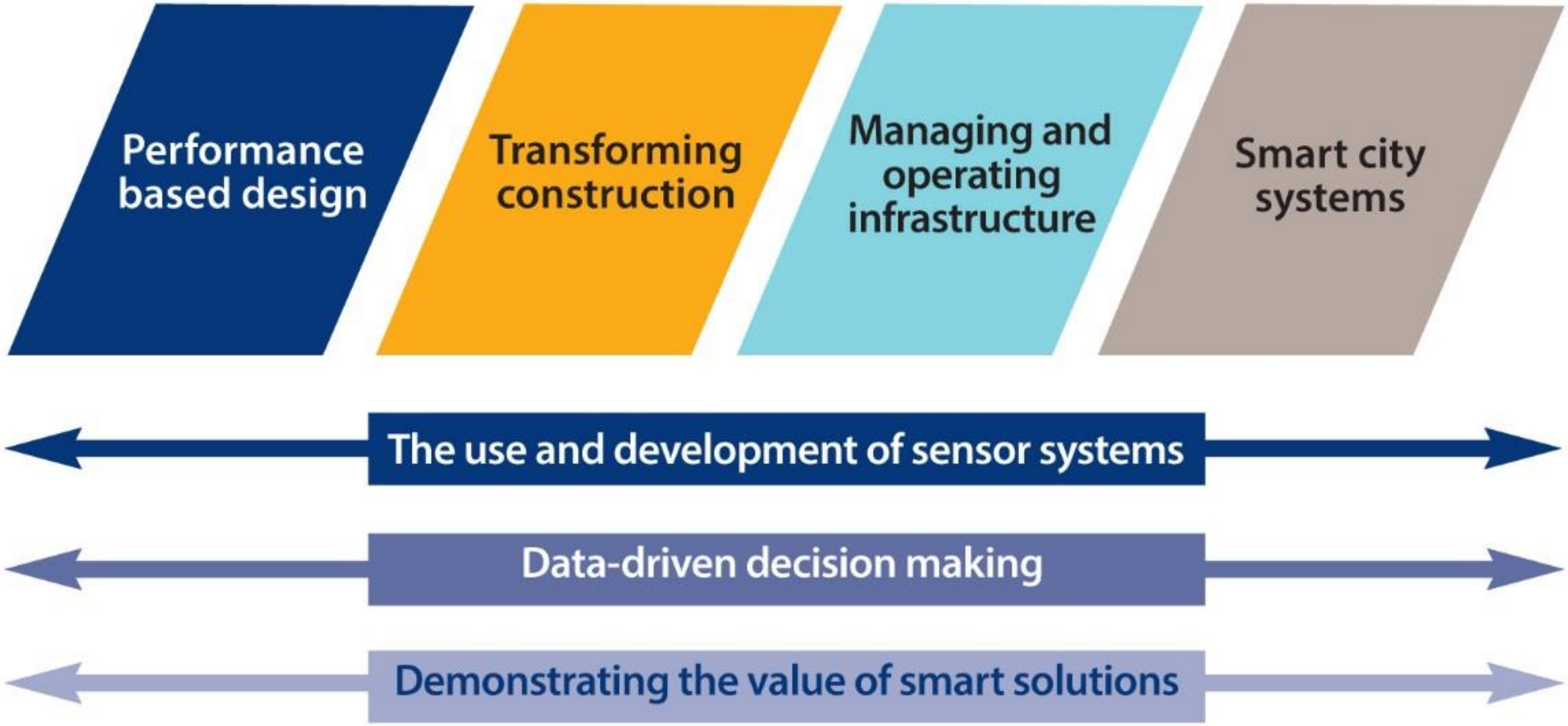
ATTACHED SENSING SYSTEMS

- Autonomous, low-cost and low-power wireless sensing technology for long-term monitoring
- Wireless fatigue sensor
- Vehicle mounted sensing
- Combined strain and displacement wireless sensors
- Temperature, tilt, etc

DATA ANALYTICS APPROACHES

- Geospatial data analysis
- Data-centric engineering – AI

So what can we do with better data?

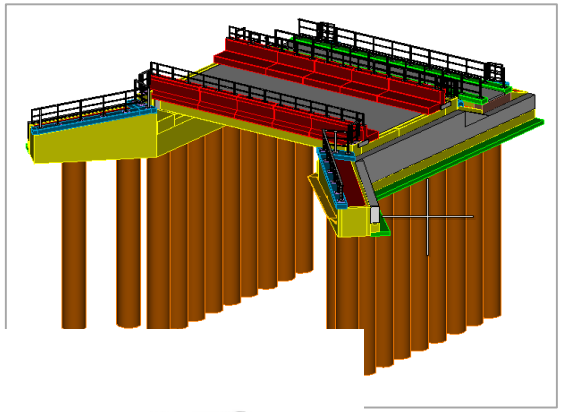


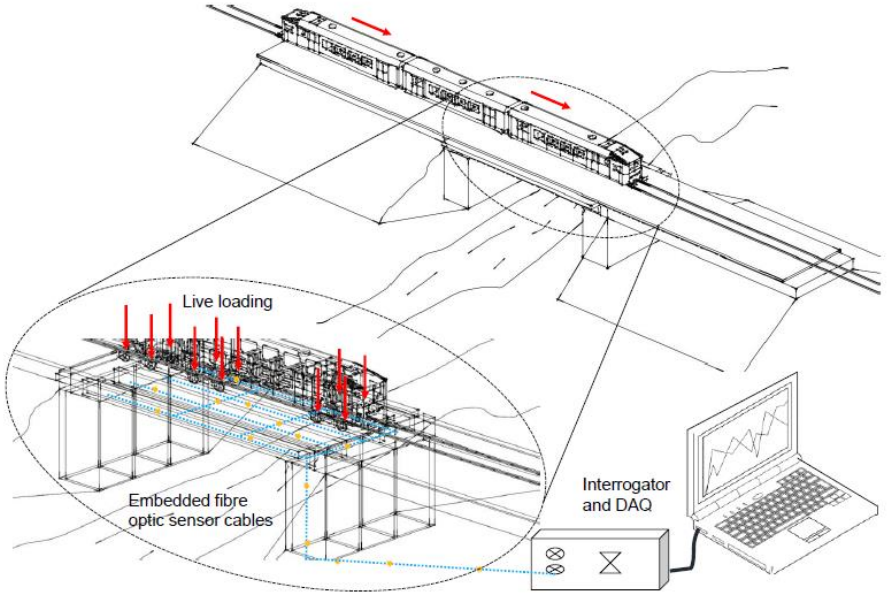
OPPORTUNITIES

Design	Construction	Ops & Maintenance	Smart City Systems
• Validating models • Demonstrate cost saving and value • Design for whole life value	• 'As-built' BIM • Quality assurance • Construction progress monitoring • 3rd party asset monitoring	• Condition monitoring and predictive maintenance • Risk-based maintenance • Futureproofing	• Demand forecasting • Optimised network management • Planning in 3-d • Energy assessments and modelling
- Better resilience, less resource use	- Reducing waste, improving quality	- Whole-life, value based asset management	- Meeting infrastructure needs

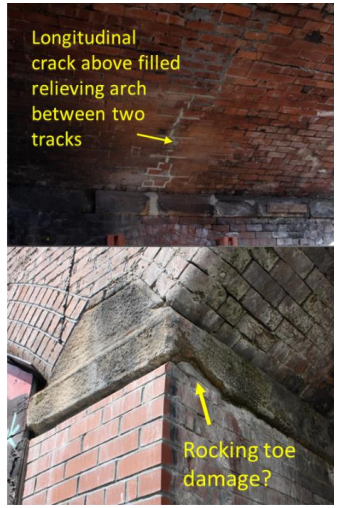
At the asset scale

Design verification & construction monitoring

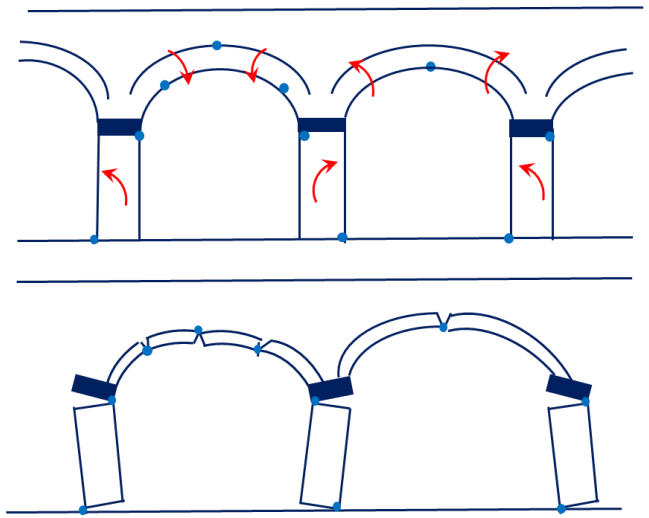


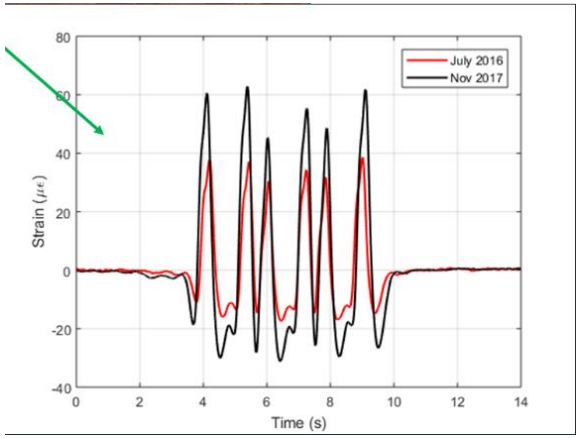


Health monitoring, capacity assessment and degradation prediction



Span opening Span closing



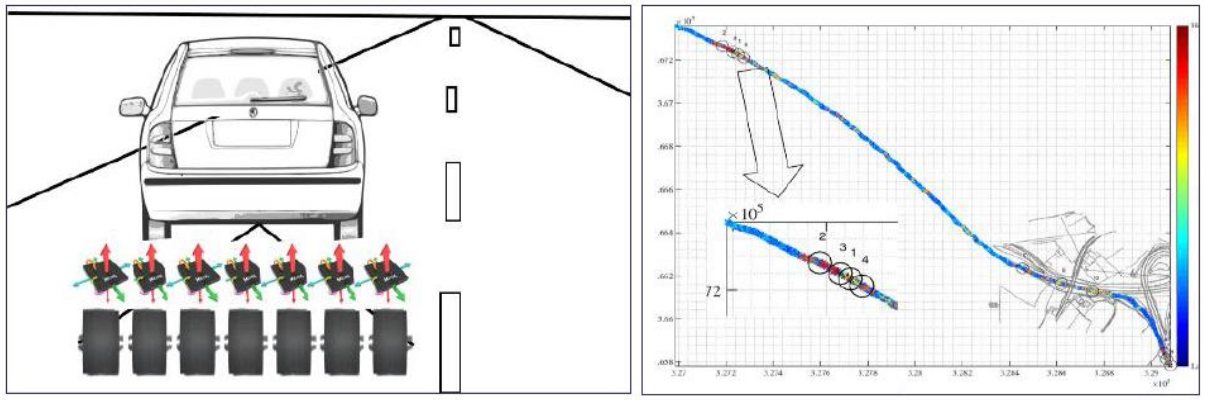


At the asset scale

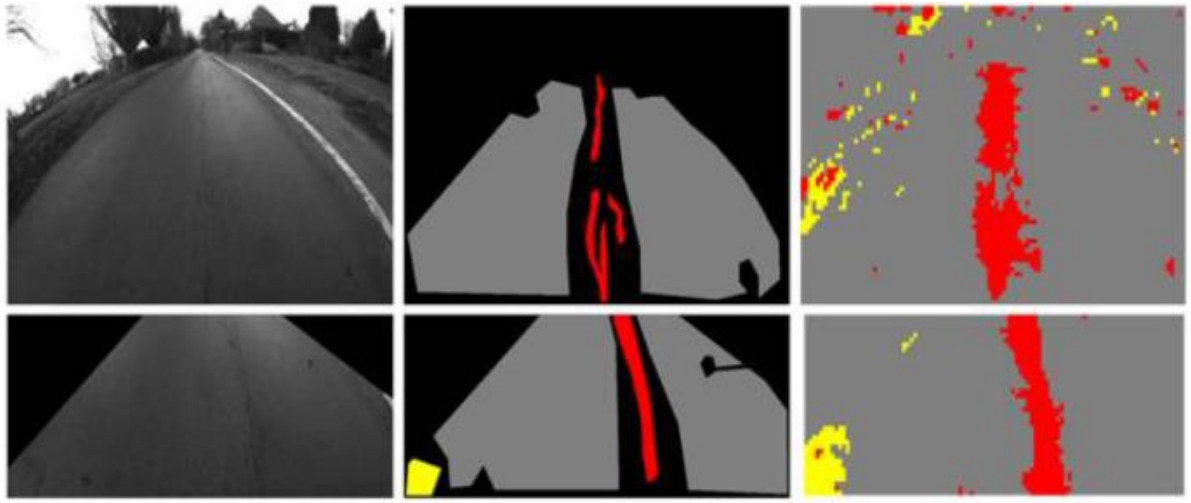
Health monitoring, capacity assessment and degradation prediction

In the UK, ***99.8%*** *of monitoring relies upon* ***manual*** *inspection with the remainder performed using expensive automated vehicles equipped with laser scanners, pavement profilers. Due to budget constraints inspection is thus limited to* ***once*** *per year .*

Vehicle-mounted monitoring techniques



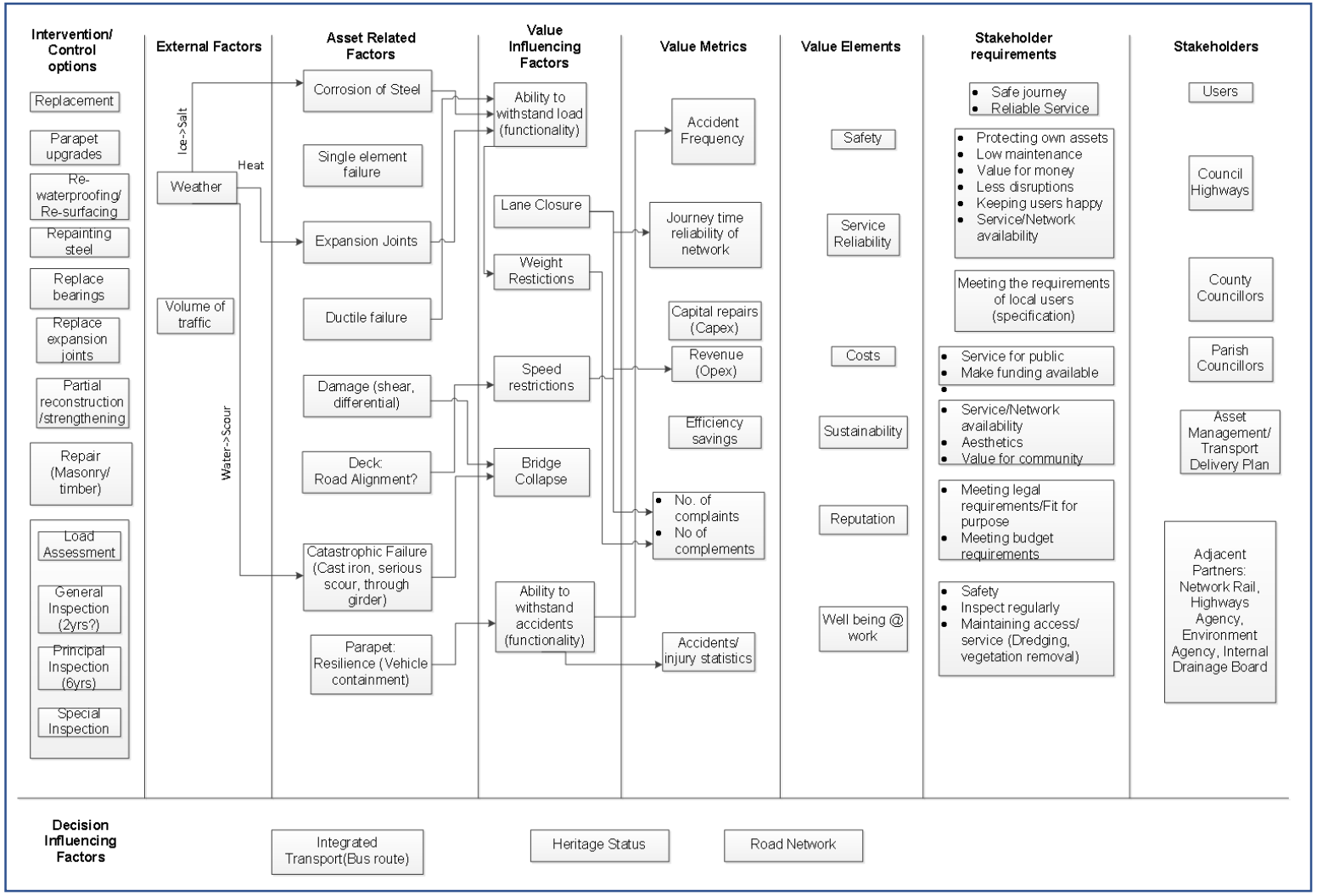
(Project carried by CSIC on the A55 in 2015)



(Radopoulou & Brilakis 2017)

At the system level

- Problem: The council has to maintain around 1500 bridges. Budget constraints limit the amount of maintenance work that can be performed each year.
- Approach: Developed prioritisation tool based on value and criticality of different bridges.
- Benefits:
  - Confidence to justify expenditure and maintenance programming of the structures
  - Target limited resources to the benefit of the local communities



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Value of bridge

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	80	High
Alconbury Bridge	Minor impact on network	Unclassified (U)	0-10 HGVs & <200 veh/day	Bus route or strategically important	Listed or heritage structure	50	Medium
Whittlesford Railway Bridge	Major impact on network	A road/Strategic A road	501-1000 HGVs & 7001-12500 veh/da	Bus route or strategically important	No heritage or local interest	80	High
Split 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	20	Low
Milebrook Bridge	No impact on network	Unclassified (U)	0-10 HGVs & <200 veh/day	Bus route or strategically important	No heritage or local interest	30	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	30	Low

Prioritisation of works

		Before (If work is not carried out)			After (If work is carried out)								
Bridge	Fa	Safety	Service	Risk Score (before)	Safety	Service	Risk Score(after)	Change in Risk	Classification	Impact of work and value of bridge	Cost	Cost Score	Final Impact
Huntingdon River Bridge	Fre	Minor Safety Problem	Major impact on service	80	No impact on safety	No service disruption	0	80	High	100	> 2M	50	150
Alconbury Bridge		Minor Safety Problem	Major impact on service	80	No impact on safety	Less impact on service	20	60	Medium	60	0.1M> <0.5M	90	150
Whittlesford Railway Bridge		Minor Safety Problem	Minor impact on service	60	Minor Safety Problem	No service disruption	30	30	Low	60	0.5M> <1M	80	140

At the city scale

Surface material + street functional class

- CA: arterial, asphalt concrete overlaied on Portland cement concrete
- CC: collector, asphalt concrete overlaied on Portland cement concrete
- CR: residential, asphalt concrete overlaied on Portland cement concrete
- OA: arterial, asphalt concrete overlaied on asphalt concrete
- OR: residential, asphalt concrete overlaied on asphalt concrete
- PA: arterial, Portland cement concrete
- PC: collector, Portland cement concrete
- PR: residential, Portland cement concrete

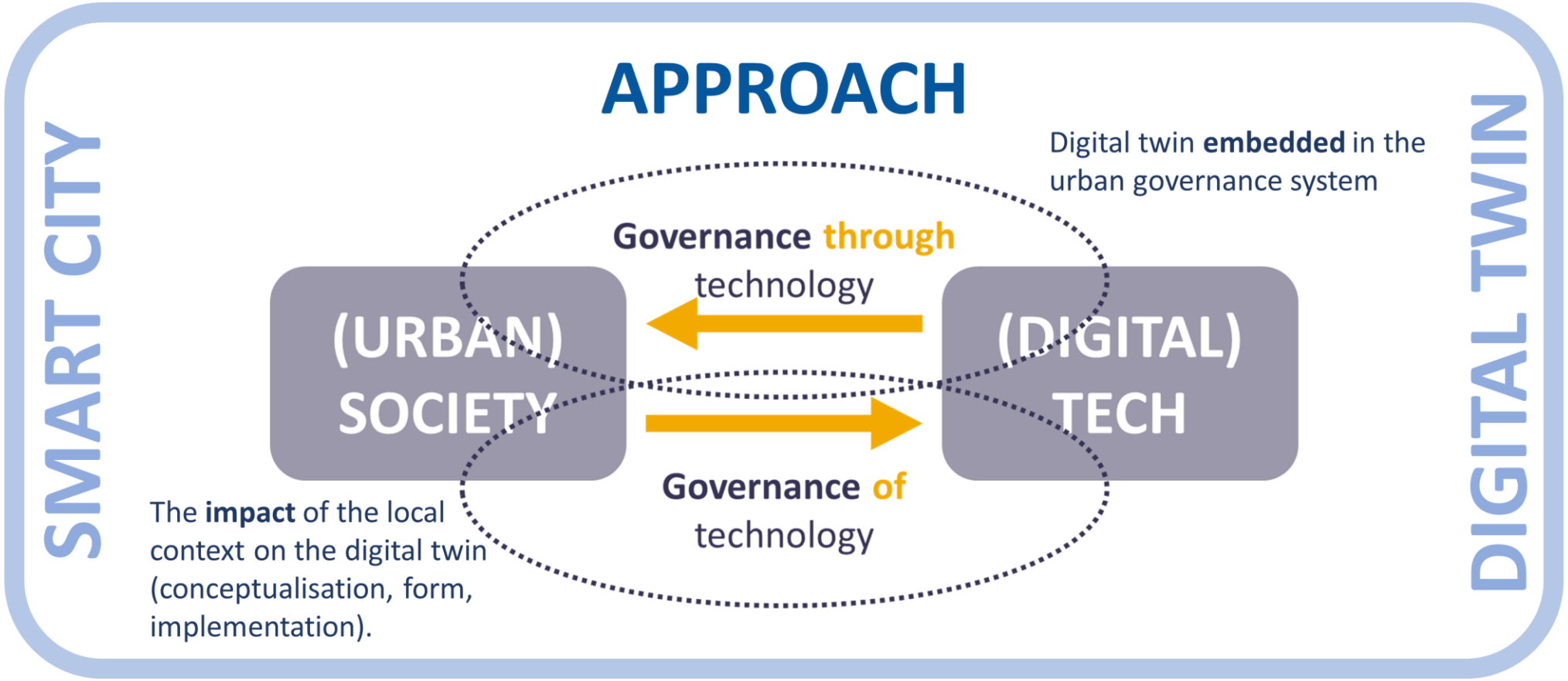
PCI change per year

-1.5

-2.0

-2.5

City scale digital twins
- the Digital Cities for Change (DC²) project

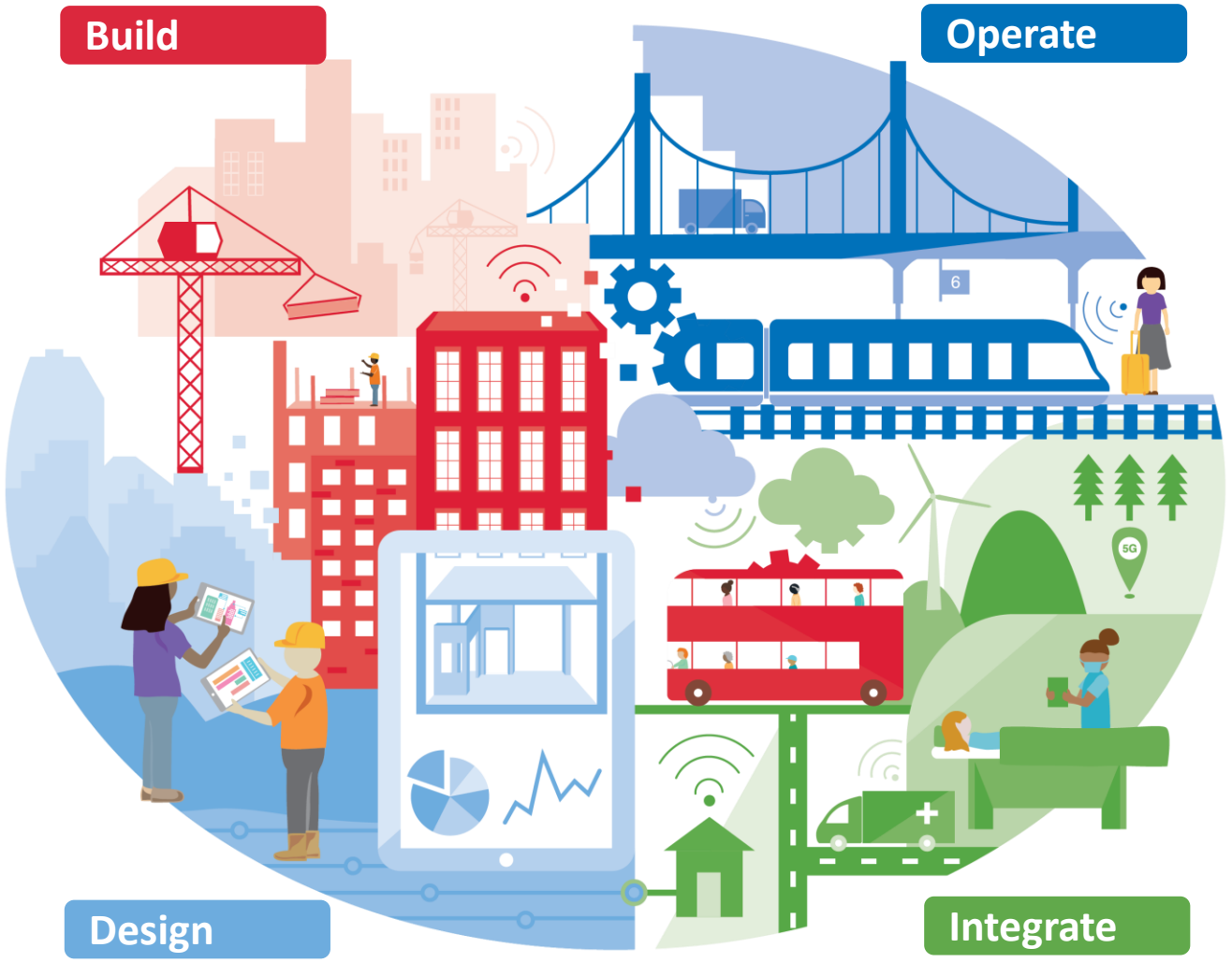


cdbb

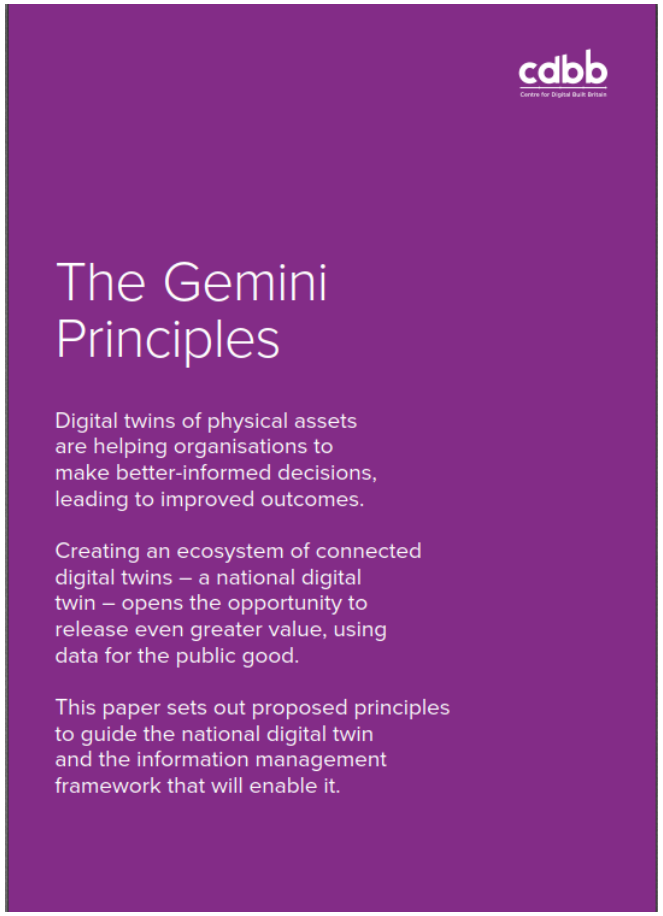
Centre for Digital Built Britain

A digital built Britain:

- understanding what information is needed right from the start
- ensuring feedback loops are in place throughout an asset's lifecycle
- information enabling better whole life value and optimising services to improve socio-economic outcomes for citizens
- exploit new and emerging skills and technology to increase productivity.



Values: the Gemini Principles



Purpose:
Must have clear purpose

Trust:
Must be trustworthy

Function:
Must function effectively

Public good
Must be used to deliver genuine public benefit in perpetuity

Value creation
Must enable value creation and performance improvement

Insight
Must provide determinable insight into the built environment

Security
Must enable security and be secure itself

Openness
Must be as open as possible

Quality
Must be built on data of an appropriate quality

Federation
Must be based on a standard connected environment

Curation
Must have clear ownership, governance and regulation

Evolution
Must be able to adapt as technology and society evolve

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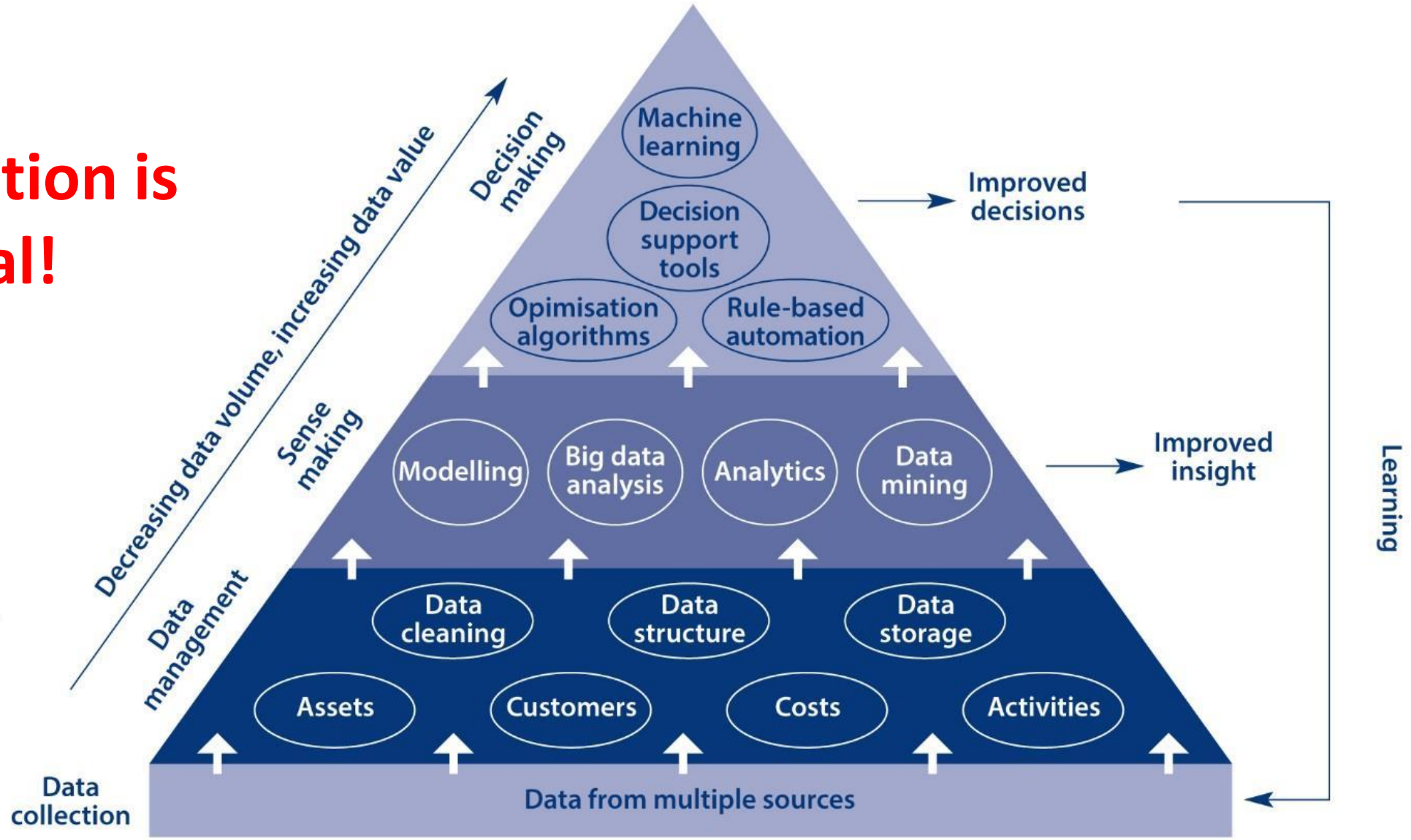

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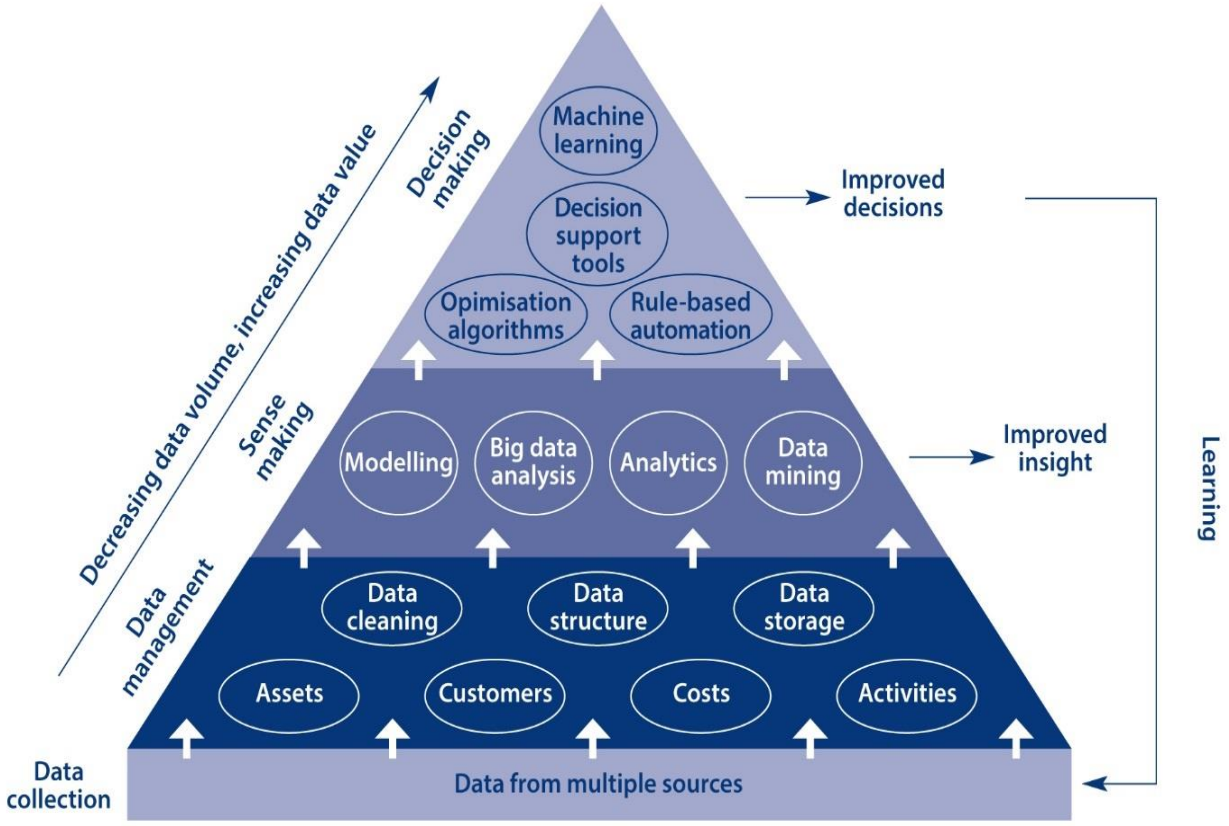

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