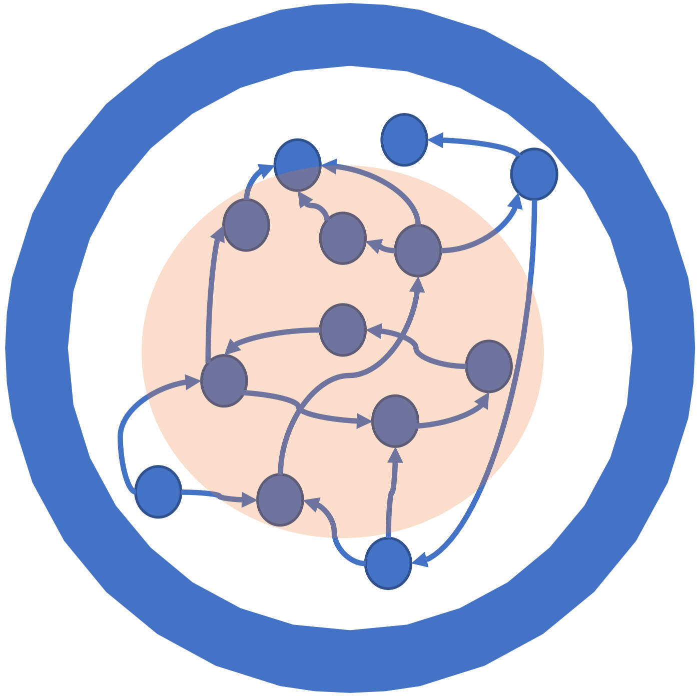
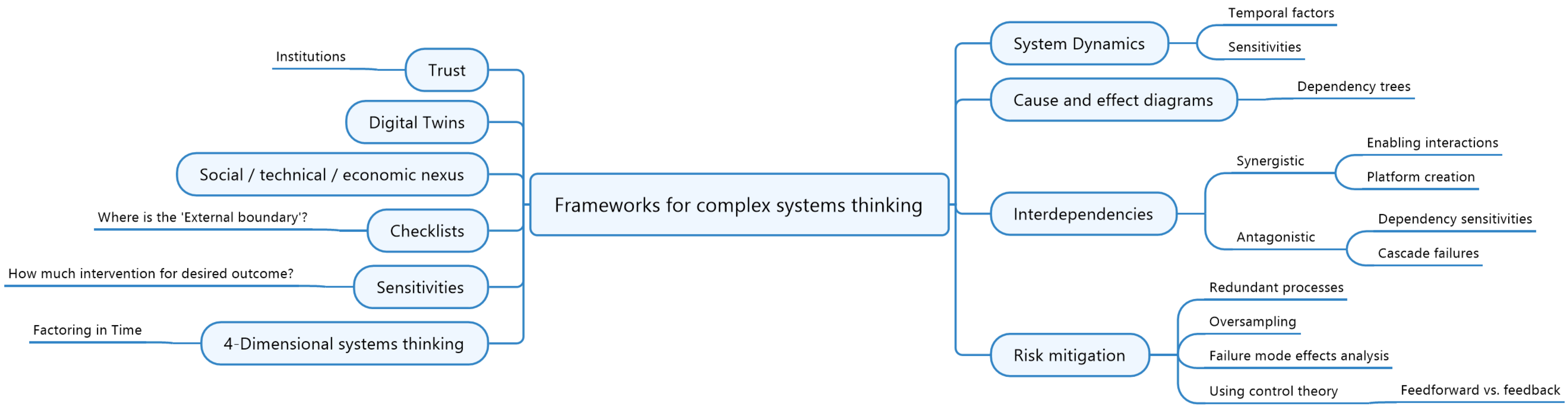


Resilience in the Built Environment

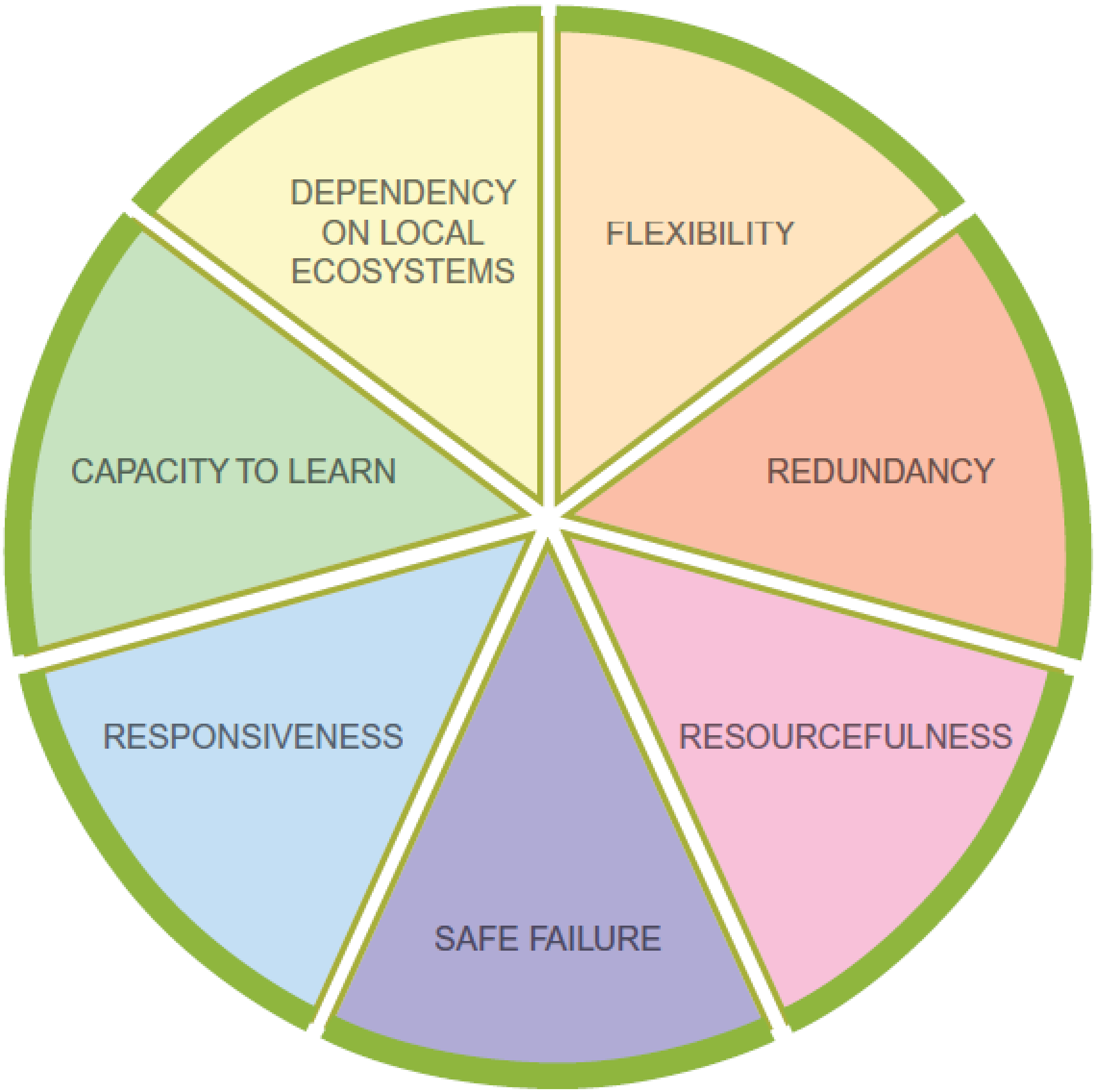
Jeremy Watson CBE FREng FIET

Professor of Engineering Systems, UCL
Chief Scientist, BRE

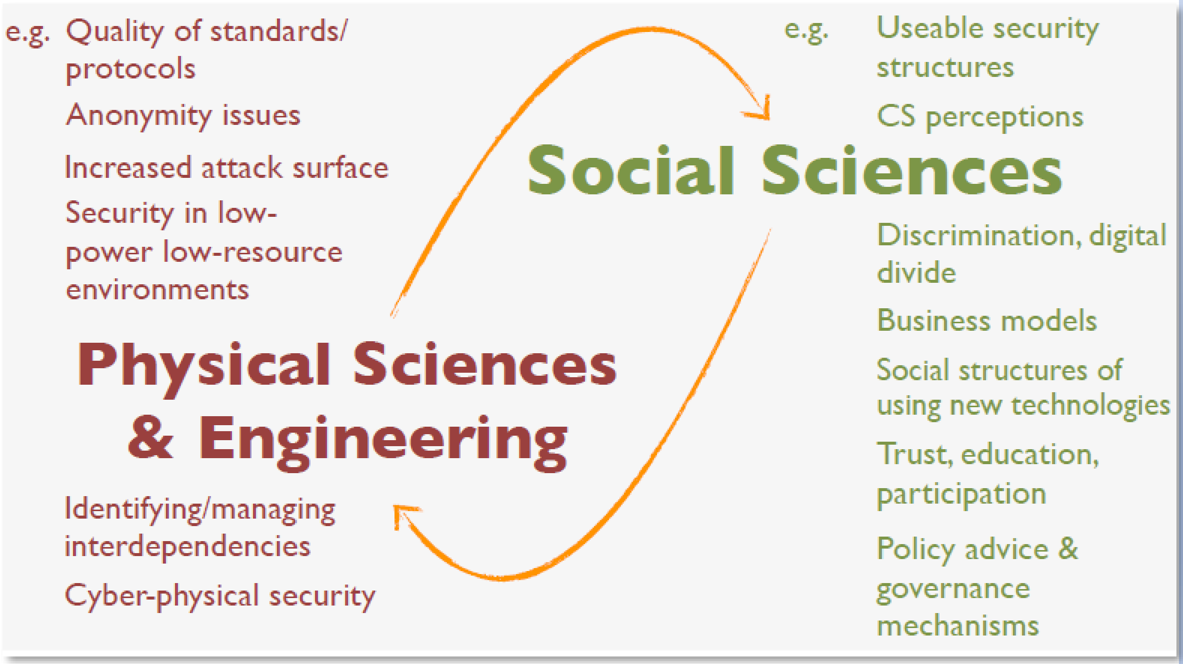
Frameworks for Complex Systems Thinking



Resilient Urban Systems: Key characteristics



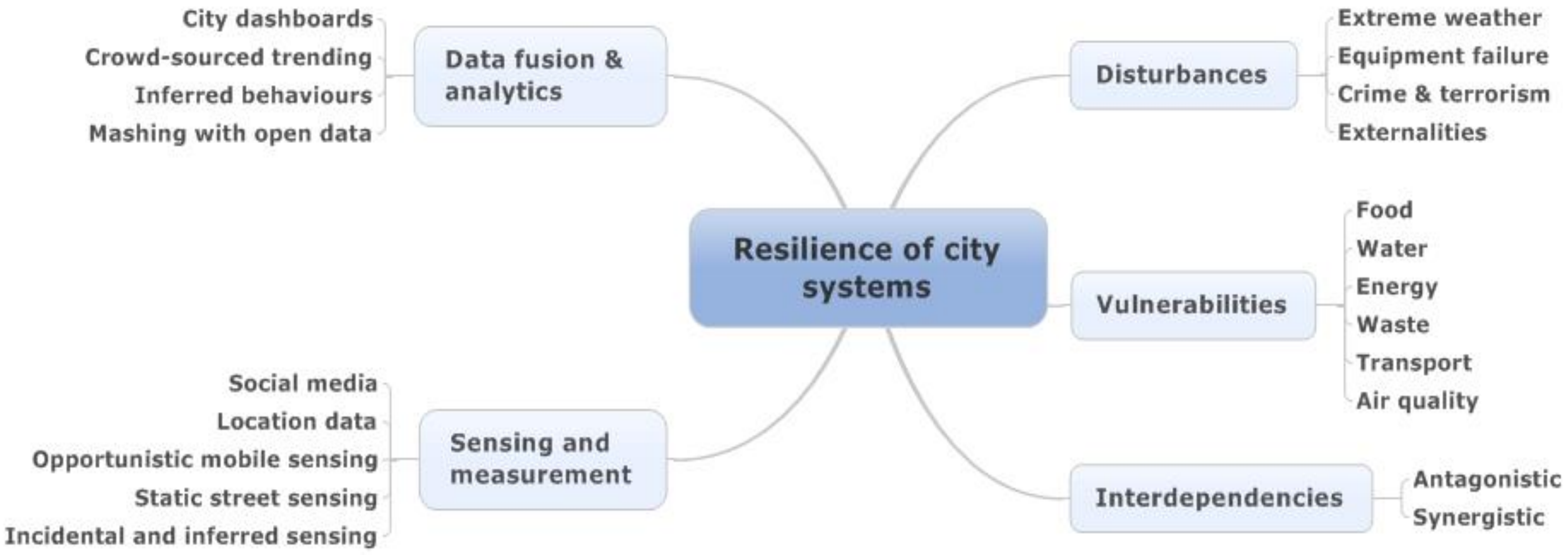
A blend of social and technical capabilities and resources



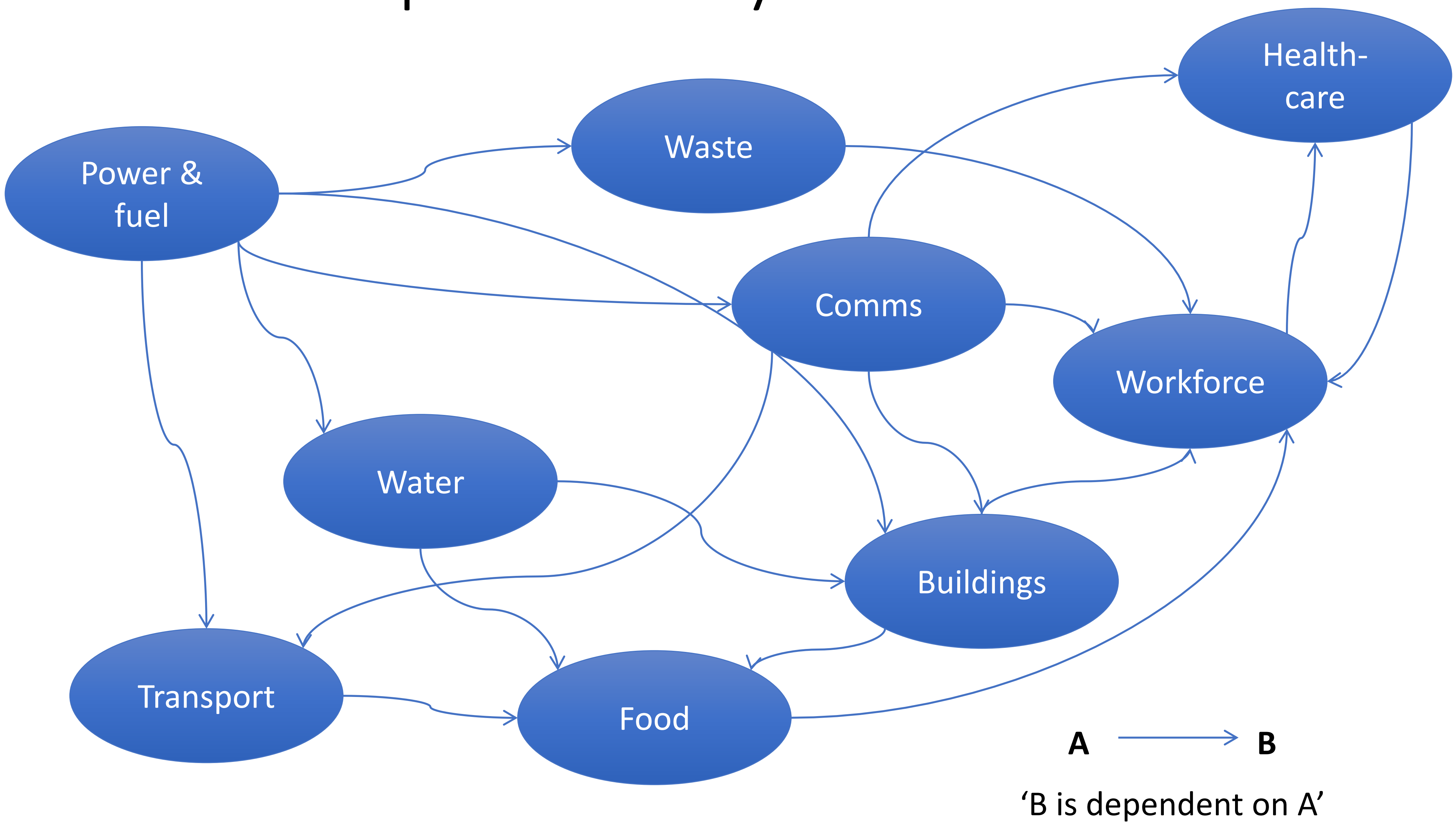
Acknowledgement: Jo da Silva, Arup

Considerations for City Resilience

*'**Resilience** - The ability of a system, community or society exposed to hazards to **resist**, absorb, **accommodate** to and **recover** from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions' – UNISDR*



Cities: Interdependent systems



Why do interdependencies matter?

- Increased risks; increased impact of perturbations
- Opportunities for decreasing costs, increasing value, improving functionality/future flexibility

Cascade risk:

- Inter-system: one form of infrastructure is able to affect another
- Intra-system: one stage of a given infrastructure system affects later stages

Single point:

- Do a number of parts of the system depend on a single asset?

Physical: Dependency on something tangible

Digital: electronic or informational connections affect others

Organisational: linkage between organisations or their processes

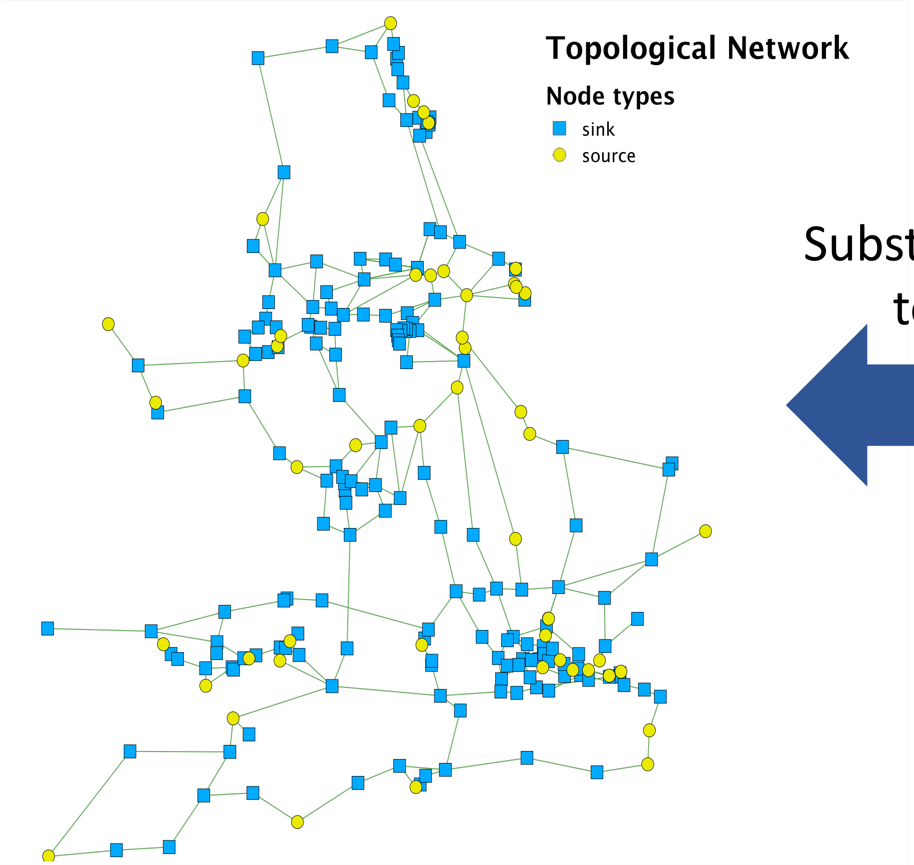
Potential opportunities

Potential risks

Acknowledgement: Richard Ploszek, IUK HM Treasury

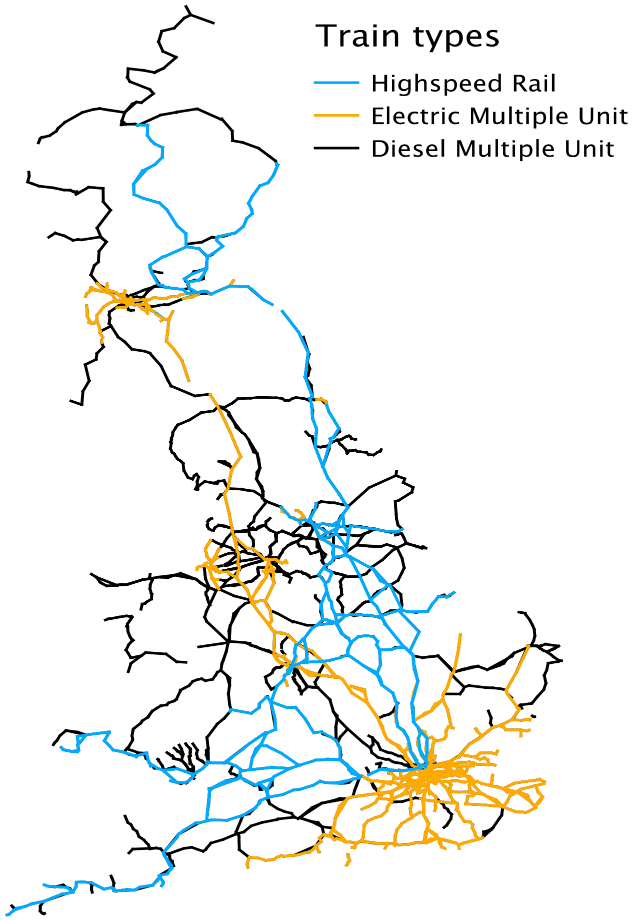
Exploring Infrastructure interdependences

Electricity transmission network



Substation linkages to rail lines

Railway network



Synergistic vs. Antagonistic interdependencies

Different 'problem spaces'?

- **Synergies** – require business models for sharing the benefits
- Need an umbrella entity – public or private sector?
- Generic issue – associated with many socio-economic systems (e.g. Health vs. Social Care)

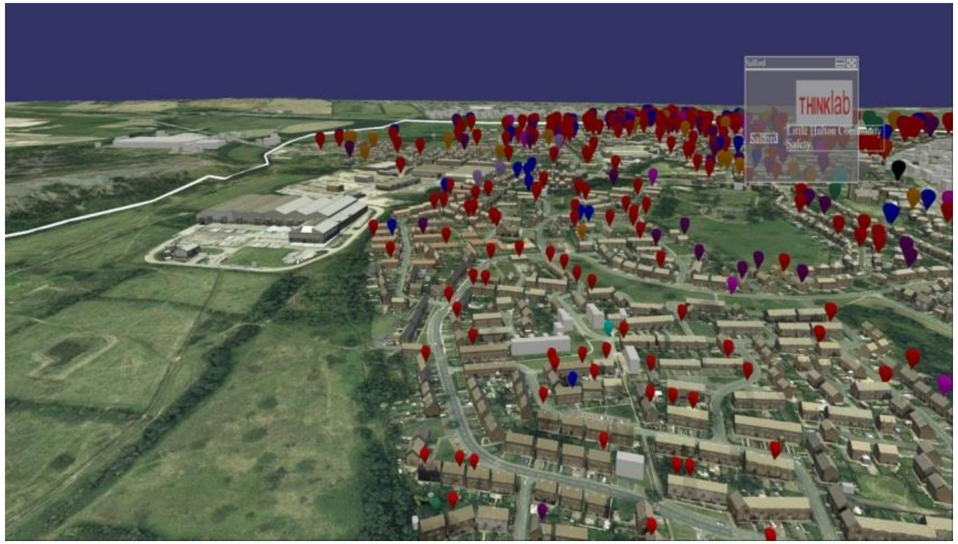
- **For antagonistics**, need to consider effect of failure of one infrastructure system on another – often an asymmetrical relationship

  E.g. Running fibre comms down a rail link

  - Failure of fibre will not interrupt rail
  - Failure of railway (catastrophic) may interrupt fibre

Data integration in Cities – and Digital Twins

Mapping Energy Efficiency of Buildings



Mapping social data (eg. Crimes)

Exploration of multiple agendas in city development (transport, housing, employment etc)

Flood simulation

Public Consultations

Value propositions for Smart Cities

- Estimated 80% of global GDP is generated in cities
- Market potential for intelligent products is large and smart solutions are a catalyst for further growth in traditional design and engineering services as well as new services
- The global market for smart city solutions and associated services may now exceed $450 billion
  - For transport as an example, a global market for smart transport solutions based on digital infrastructure is estimated to exceed $4.5 billion
  - A wider market exceeding $100 billion includes the physical and digital infrastructure for parking management and guidance, smart ticketing, traffic management and associated engineering services

Ambient Environments

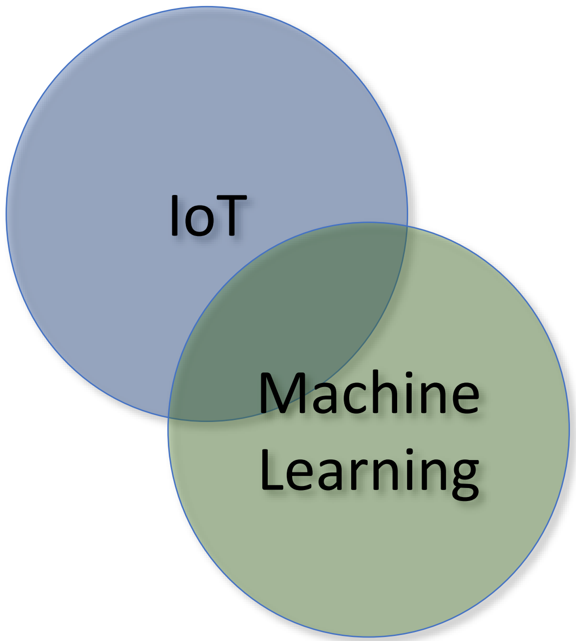
Cities, neighborhoods, homes, and the environment will be affected by the integration of IoT

Research questions

- How do we measure the impact of ambient technologies on user perceptions of security, privacy and agency?
- How can sensed data link to and inform higher level decisions made locally or in the cloud?
- Can we determine the trustworthiness and value of information from ambient sensors, considering provenance and data quality?
- Can we contextualise and influence user behaviour in an urban environment?
- How can dynamically varying risk in smart home technologies be conveyed in a useful way?

Emerging IoT Applications & Edge Technologies

- **Smart Facilities Management**: Performance assurance and predictive maintenance of capital assets, e.g. Buildings, Transport and Utilities infrastructures
- **Tracking high-value assets:** assurance of supply chains
- **Whole-life wellness management**: Fitness, Telemedicine, Telecare



Promoted by new technologies at the Edge of the Internet

- **Distributed Artificial Intelligence, Machine Learning and decision support – 'Thinking Things'**

These technologies bring new adoption, acceptability and security challenges

Key R&D challanges around emerging Edge Technologies

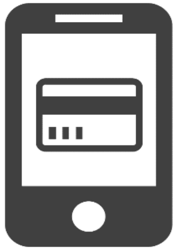
- **Sensor data provenance and 'Data Quality'**
    - Establishing the 'DNA' of sensor data streams and metrics for quality
- **Live data management and fusion with Digital Twins**
    - Requirement for secure information ontology frameworks
    - Melding of live data streams with static data sets – CAD/BIM/GIS, etc.
- **Enhancing information quality from sparse sensors**
    - 'Triangulation', interpolation and citizen sensing
- **Achieving user and societal trust in devolved machine learning**
    - AI and Machine Learning analytics take agency on behalf of humans
- **Protecting privacy and security of individuals and critical national infrastructure**

Acknowledgement: Boston Dynamics

Edge Technologies – Policy challenges

- Need for dynamic and effective policies (c.f. pandemic response) Requires trustworthy, timely evidence from data sources
- Expectation of sharing and combining data from sources to improve public and citizen services, and to infer new understanding
- Need for rigorous privacy and security measures to protect citizen information and critical national infrastructure
- Adapting policies to emerging socio-technical trends; e.g. smart phones and pervasive IoT in domestic devices
- Regulating currently un-restricted and unauthorised (e.g. M2M) data-sharing
- Driving best practice through government procurement policies

Emerging trends and opportunities



'Digital at the Edge' trends

IoT becomes pervasive, multifactorial and smarter

Machine Learning and Decision Support embedded in Edge devices

Data concentration and local inference engines

Reflexive control allowing dynamic air-gapping to protect against cyber-attack without losing functionality

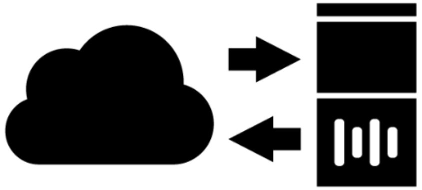
Edge Technologies

Sensor and actuator (IoT) devices will ‘know’ their functions

AI can assure IoT network transactions in real time

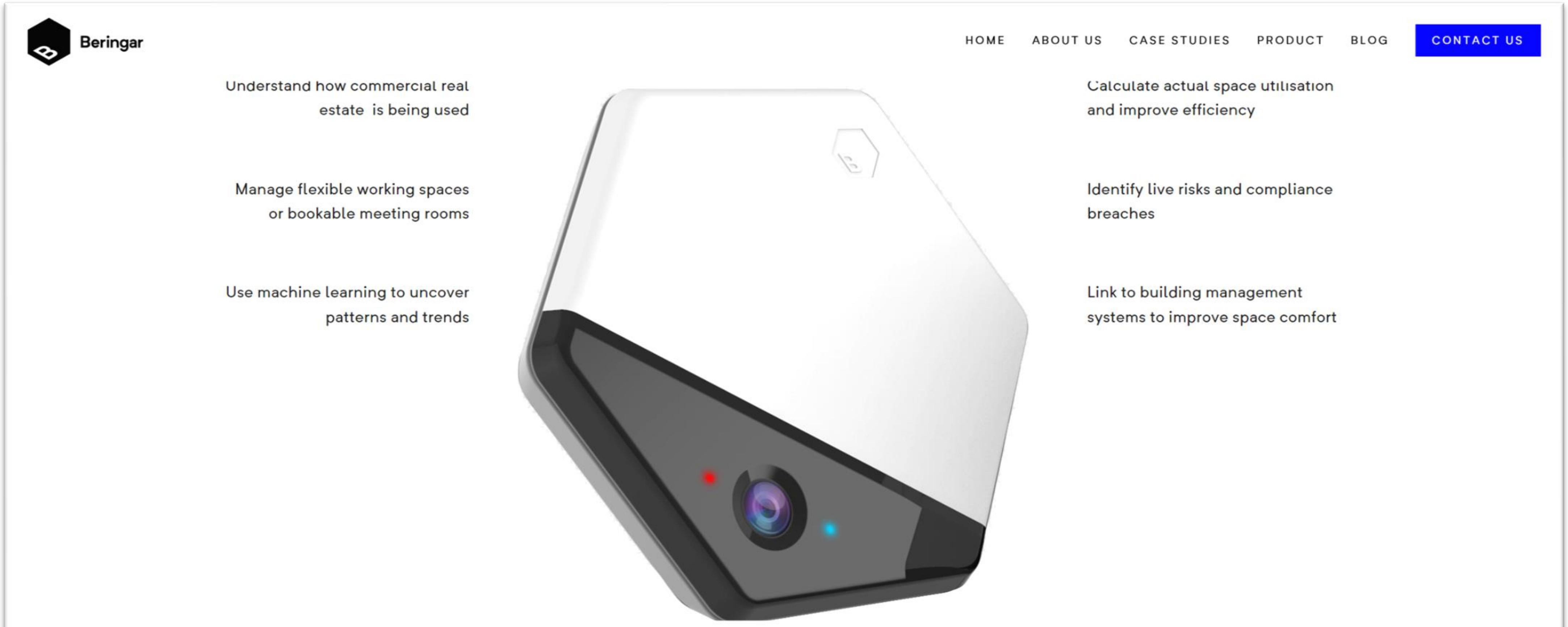
AI in Edge nodes can perform data concentration and automated diagnostics and systems tuning to improve performance

Local intelligence can provide resilience.



Edge Technology IoT/ML example: Beringar

- Occupancy detection and counting with data reduction
- Anonymity maintained
- Typical applications – Office or Rail platform occupancy



Cybersecurity of IoT is Vital

Make IoT Secure by Design, and the need for regulation

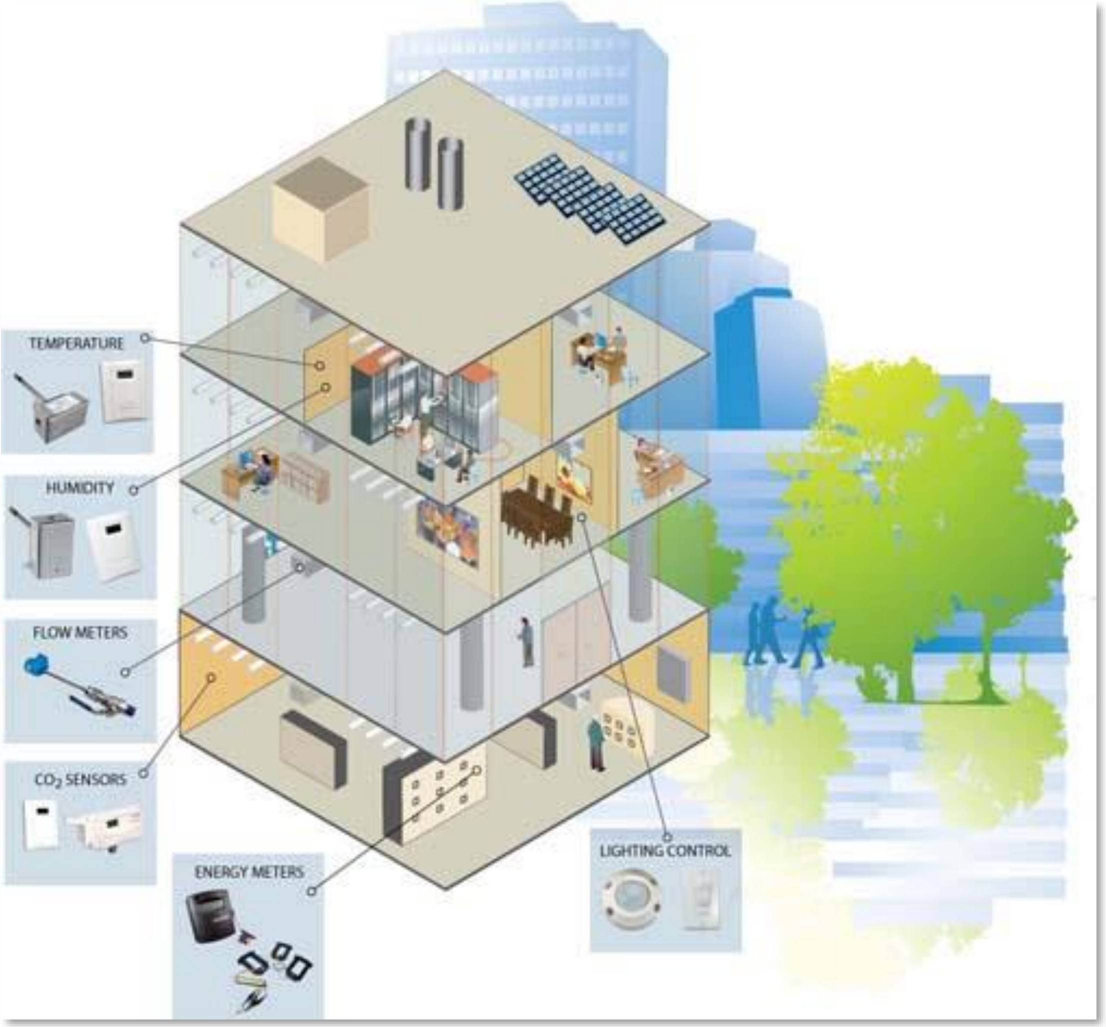
- Information theft
- Recruitment of IoT devices – Botnets (e.g. Mirai)
- Perturbation of operation
- Corruption and falsification of sensor data
- Falsification of information
- IoT can be a point of entry to compromise a network

- Contactless card skimming
- Hacking Building Management Systems
- Smart toys
- Baby monitors
- Smart TVs
- USB devices
- Healthcare devices - Fitbits to infusion pumps
- Smart domestic goods
- Cars, now and in the future

Hacking into Building Management Systems

Disabling a server room chiller can shut a business down

- IBM Ethical Hacking team Pen test
- BMS connected to enterprise IT – a ‘back door’
- Poor ‘Cyberhygiene’ on part of BMS installer – weak password
- Weak router security between BMS and server
- Clear lessons learned



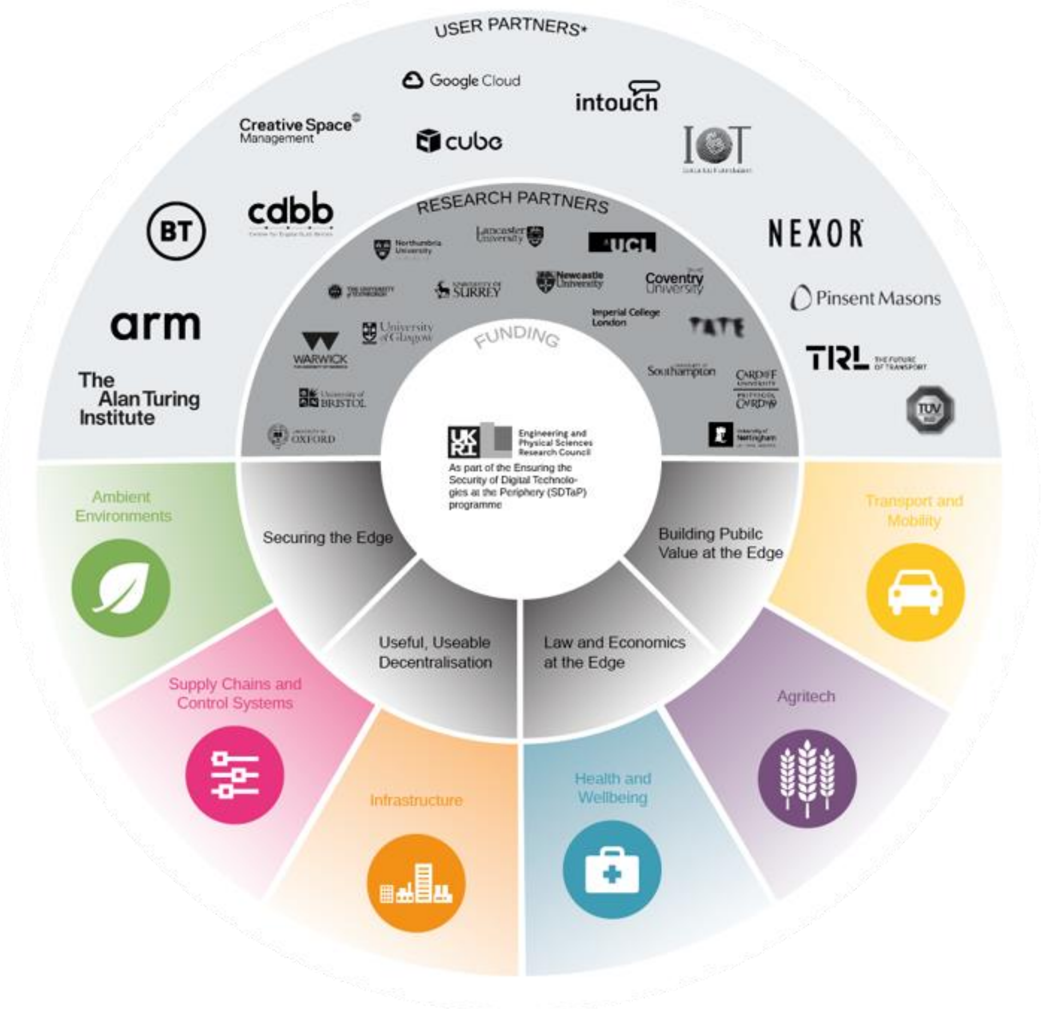
https://regmedia.co.uk/2016/02/10/567584334543.pdf

PETRAS Community 2016 - 2023

The UK National Centre of Excellence for IoT Systems Cybersecurity

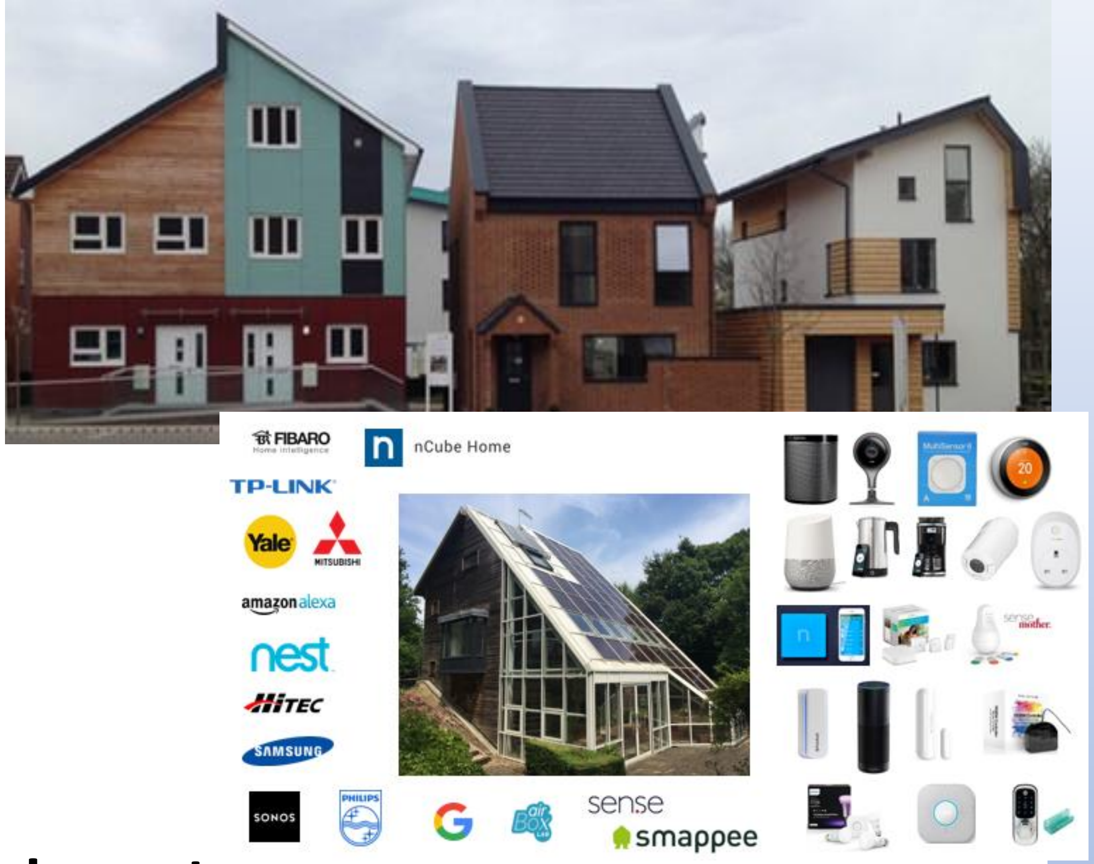
- **20 Universities, led by UCL**
- **£35m, 7 years**
- **>100 Partners**
- **100 Projects (more on the way)**
- **5 IUK (£10m) Demonstrators**
- **6 Sectors & 4 Lenses**
- **Multiple areas of capability & expertise – Socio-technical**

*a selection of partners/universities



IoT in the Home

The context of the demonstrator project is BRE’s Innovation Park, which includes more than 8 domestic buildings, 3 of which have integrated photovoltaic power generation (PV) with battery storage and network import/export management.



Deliverables:

- Real full-scale ‘Smart Home’
- Smart Home simulator
- Use case – Micro energy-trading in a community
- Report on factors influencing adoption & acceptability
- Guidelines for secure IoT deployment

Impact:

- Design, procurement, deployment and operation
- Government and Industry policy advice

Logistics 4.0: Securing High Value Goods using Self-Protecting Edge Compute

Developing IoT technologies to better protect high-value goods by providing environment, transit behaviours, and wide-area real-time location data. Tiny sensor-tracking (attached directly to objects) devices protect the object and can also protect themselves.

- Identify pieces
- Monitor location and movement
- Observe condition across borders in a seamless, secure, and cost-effective way

Protecting the irreplaceable!

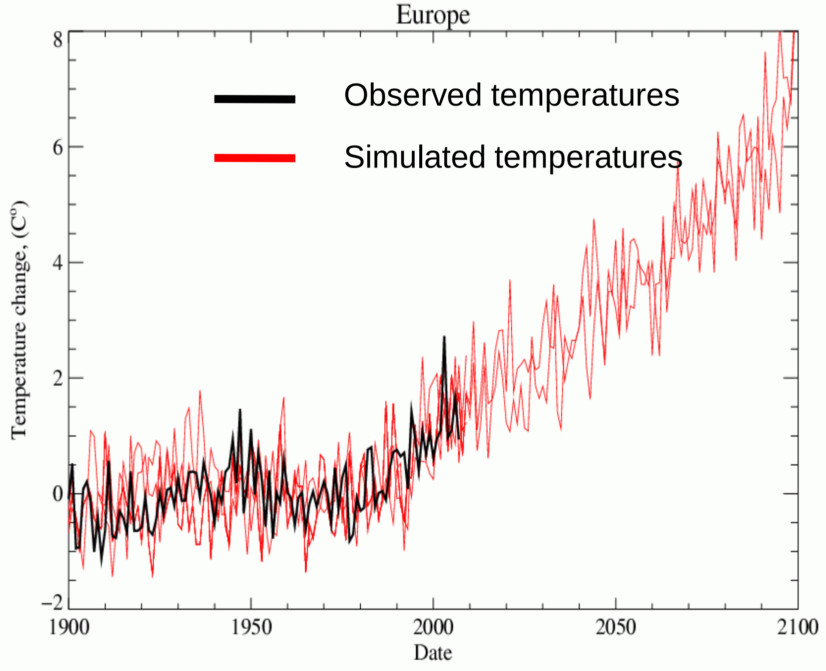
Covering security from 3 different angles:

- Design for Trust
- Technical Co-Design
- Law, Ethics and Risk

Professor Julie McCann
Kate Parsons
Imperial College, Tate

Partners: Tate (Collections Management), Ordnance Survey, Constantine Ltd, MOMARTplc, ARM

Met
Office



Summer 2003: normal by 2040s, cool by 2080s

A Challenge: Net Zero GHG Emissions by 2050

- Legal Requirement in the UK
- Net Zero by 2050 explained: [net-zero-by-2050-explainer (raeng.org.uk)]
- Challenges involve socio-technical, economic, political, policy considerations
- Solutions need to use a HOLISTIC and COHESIVE systems approach across all sectors of the economy, connecting learning from each
- Suggests the value of a ‘What Works Centre’ approach

The WWC model

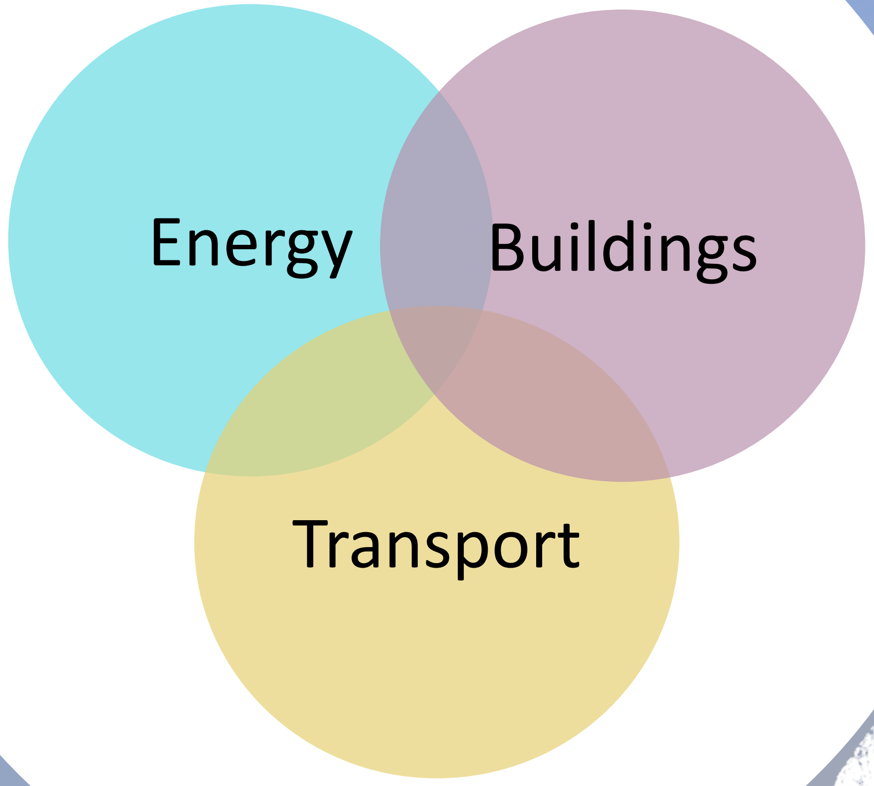
What Works Centres use a neutral holistic approach to provide impartial advice and to grow national capability

- Generating evidence on ‘What Works’ in defined contexts and policy areas
- Translating evidence for specific user groups
- Encouraging adoption and intelligent use of evidence, creating capability
- Maintaining focus and providing impartial advice for policy and best practice

The Sectors

To be effective, 6 major sectors need to be considered, including their interdependencies:

- Building (construction)
- Transport
- Industry (manufacturing and process)
- Utilities (including energy supply)
- Services industry (office, retail and finance)
- Agriculture



Addressing a cross-sectoral challenge

A Starting point:

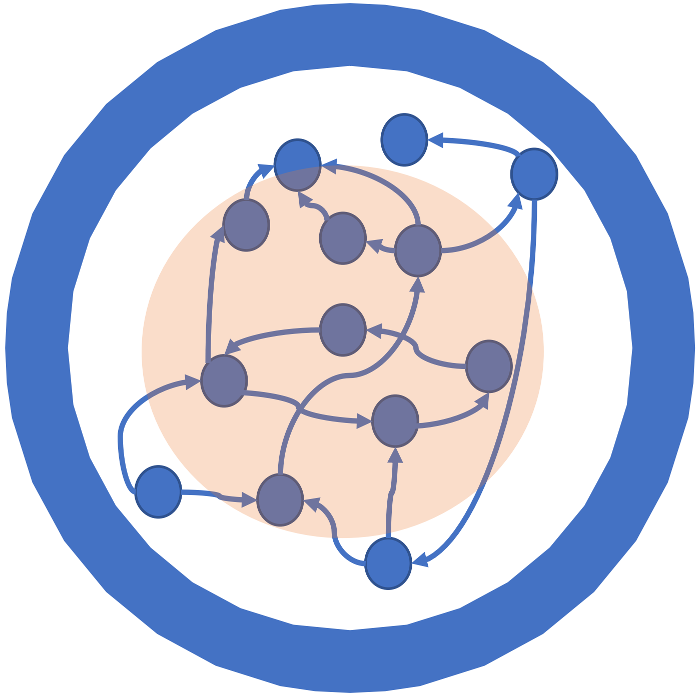
The BUILT ENVIRONMENT intersecting with ENERGY and TRANSPORT

- Taking a Systems View
- Sharing Learning
- Close To Practice
- At scale
- At pace

Other sectors to follow, benefiting from learning

Early Deliverables

- Respond to under-addressed demand for advice on Net Zero strategies => local authorities and landlords
- Transferrable learning points emerging from the common challenges and understanding of socio-technical and cross-sectoral interdependencies



Thank you

Resilience in the Built Environment

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