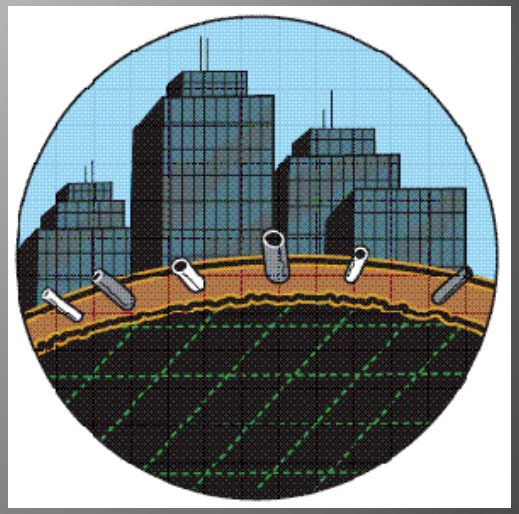
Infrastructure –
Futures
Utility Services
Transport
National and Local
Sustainability and Resilience



Urban Futures

Professor Chris Rogers
University of Birmingham
26th September 2011

Resilience Through Innovation

Critical Local Transport and Utility Infrastructure

Servicing our Cities

Urban Futures

What is the purpose of cities?

Engineers need to provide

... a source of clean water
... energy (gas, electricity ... even fuel)
... telecommunications
... removal of wastewater (sewage)
... removal of storm water (drainage)
... removal of solid waste
... street lighting

... a variety of means to move around (walking, cycling, cars, trams, buses, trains, rollerblades, pushchairs)

... and a means to control the interfaces (traffic lights, traffic control, CCTV)

Servicing our Cities

Urban Futures

We want these services to be hidden

... a continuous, but invisible, provision of our needs

Our services are provided via buried pipelines

... plastic, cast iron, vitrified clay, concrete, asbestos cement, glass fibre reinforced plastic

or via cables

... electricity, fibre optic, street lighting, traffic lights

These buried services are national as well as local

... except for electricity cables on pylons

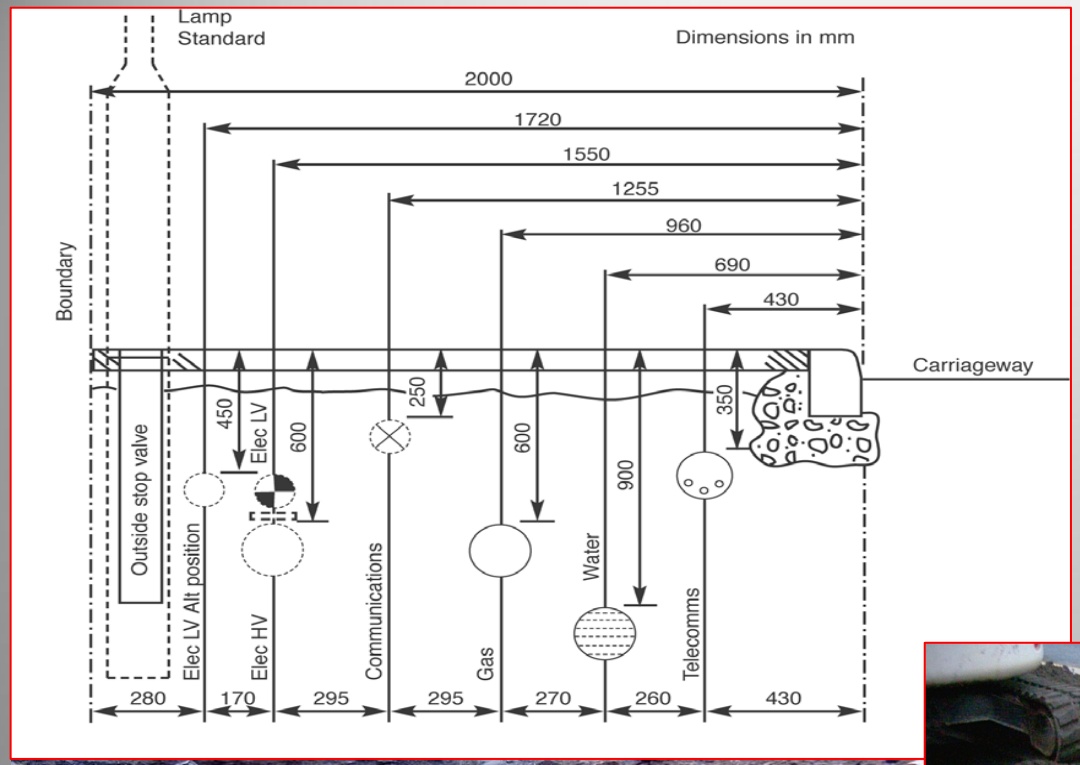
... £108k from EPSRC on feasibility of long-distance trenchless installation of high voltage cables

We bury them along our common ground in cities

... beneath the transport corridors, specifically roads

... and our roads are congested

Urban Futures


Lamp
Standard
Dimensions in mm
2000
1720
1550
1255
960
690
430
Boundary
Carriageway
Outside stop valve
Elec LV Alt position
Elec HV
Communications
Gas
Water
Telecomms
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450
600
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600
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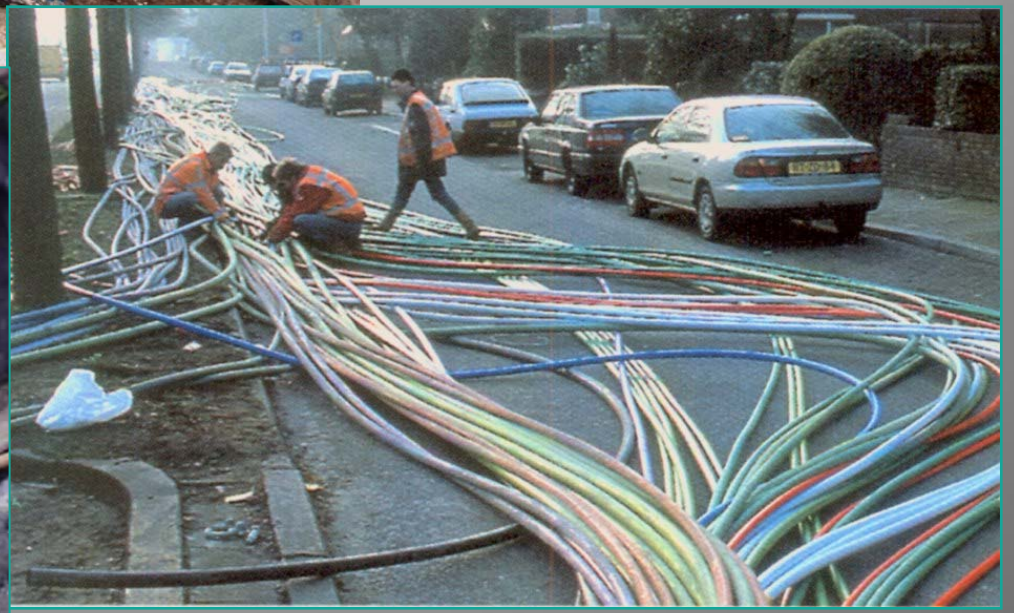
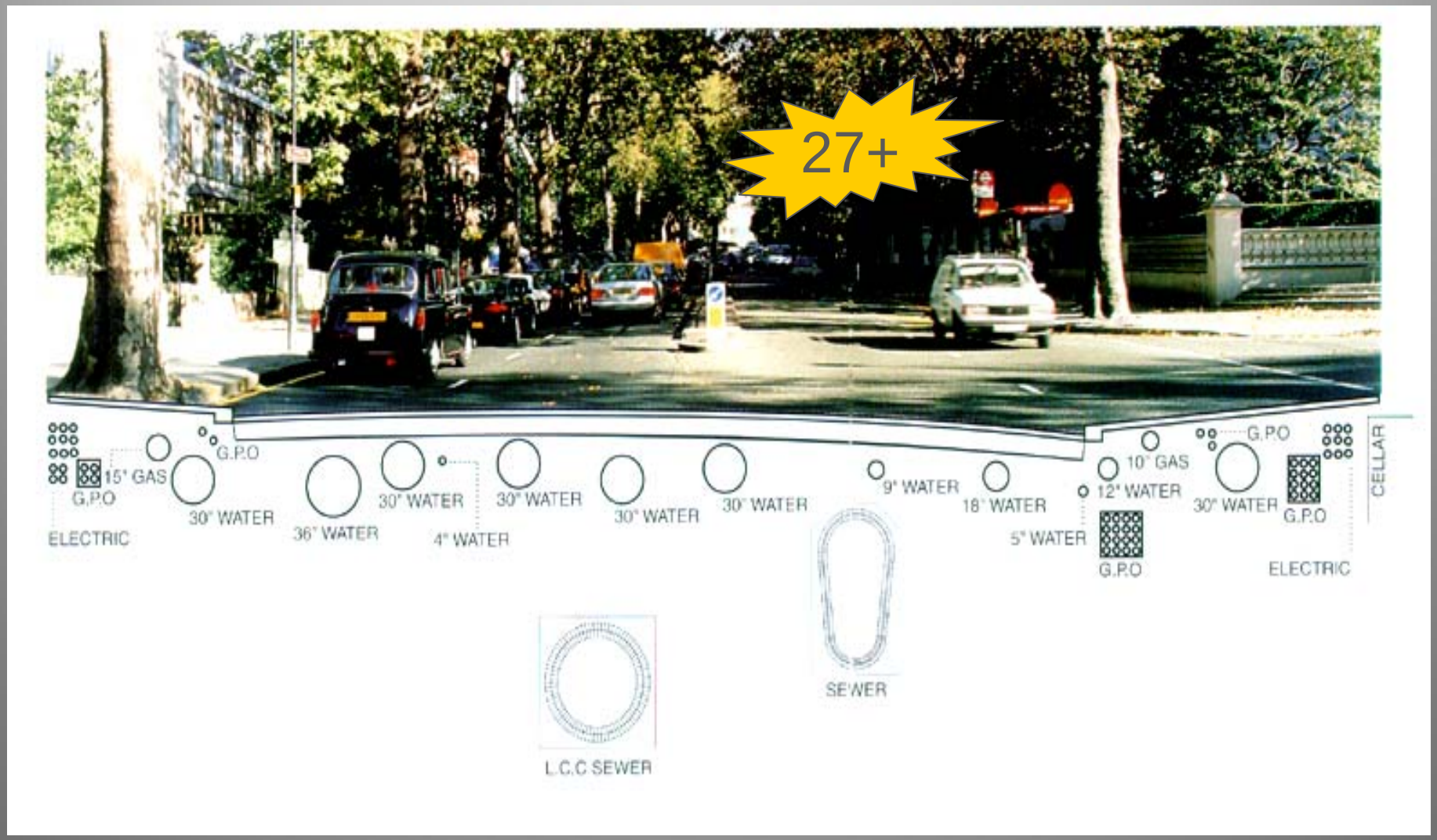
170
295
295
270
260
430


JCDecaux

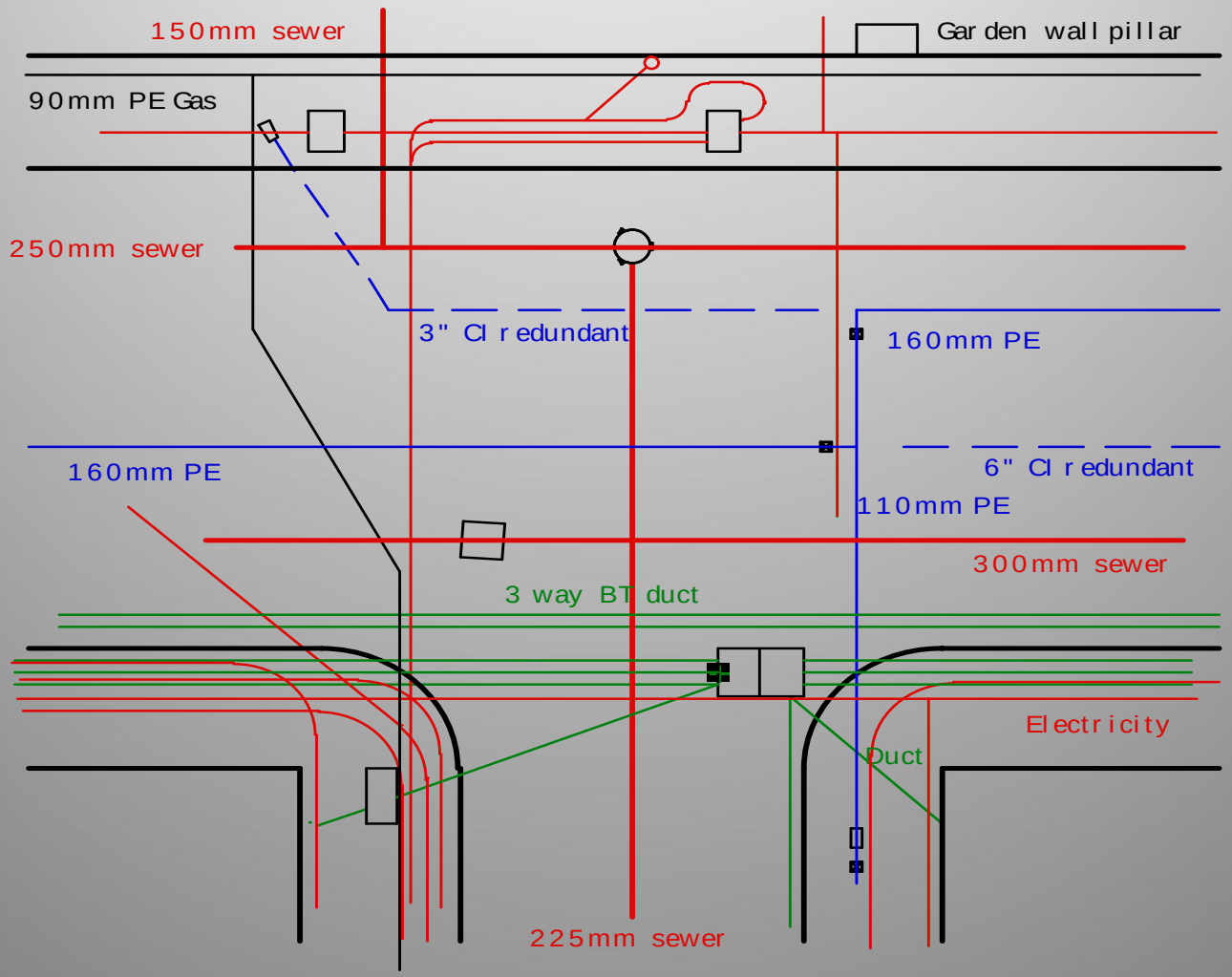


Urban Futures

Mapping the Underworld



Mapping the Underworld



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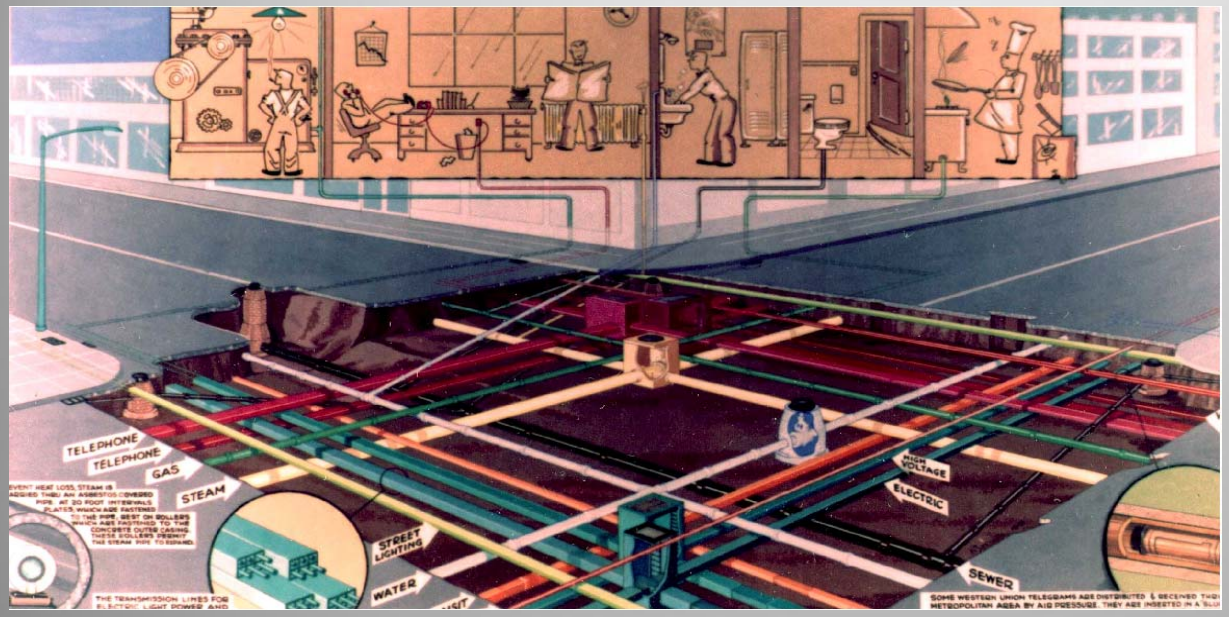
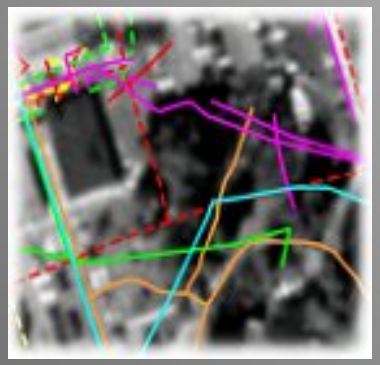
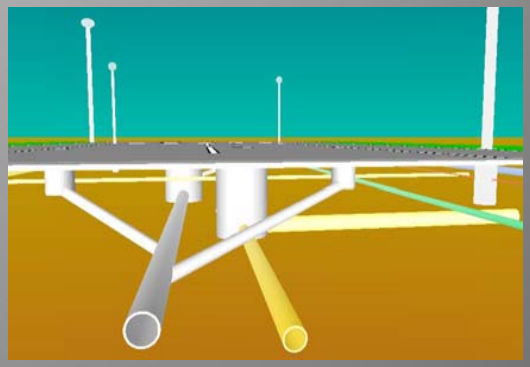


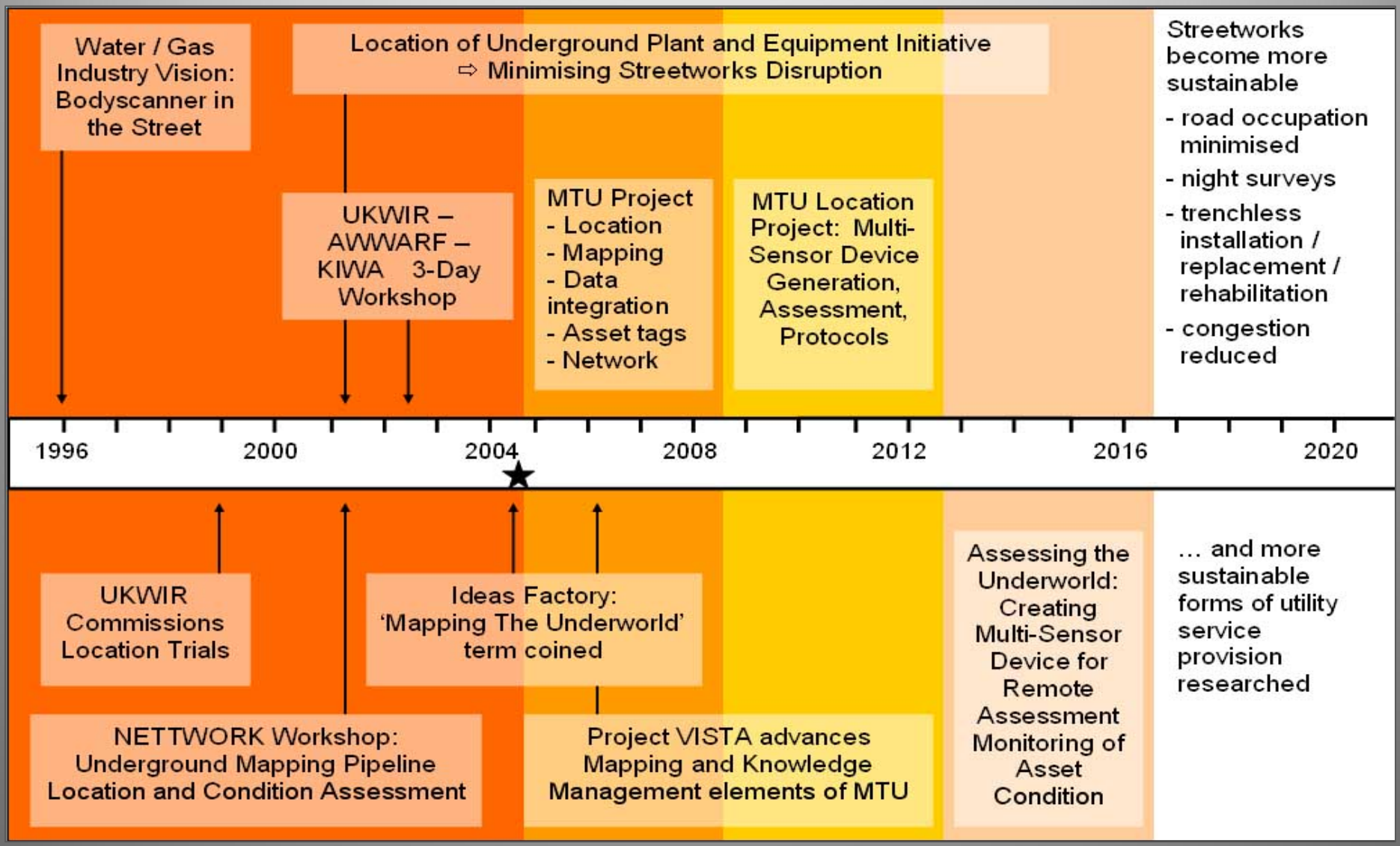
Image from www.seattle.gov/transportation/stuse_utilpermits.htm



- Web-based illustrations
- 3-D maps (virtual reality)
- Probability maps of where utility service pipelines and cables may be present or absent



Mapping the Underworld



Development of a Multi-Sensor Device

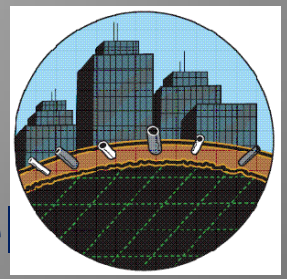
MTU Phase 1 – £1.2 million (2004-08) for 4 'feasibility' projects
MTU Phase 2 – £3.5 million (2008-12)

One sensor will not locate all utilities
... *but operating several at once might*

Four sensor technologies are being investigated:

- Ground Penetrating Radar (GPR)
- Vibro-acoustics
- Low Frequency Electromagnetic Fields
- Passive Magnetic Fields

Data fusion, fusion with records, intelligence on ground properties, KBS, training centre ... all hel



UNIVERSITY OF BIRMINGHAM · UNIVERSITY OF BATH · UNIVERSITY OF LEEDS · The University Of Sheffield. · University of Southampton · UKWIR · EPSRC Engineering and Physical Sciences Research Council

Gravity Gradient Technology

EPSRC grant of £2.4 million
Physics, Civil Engineering, Archaeology

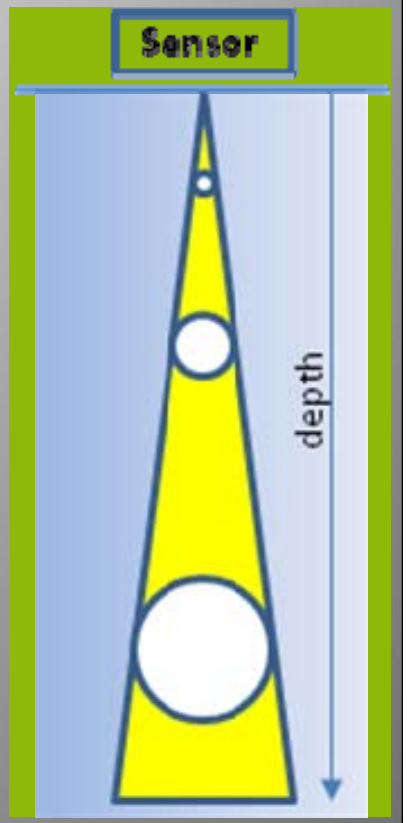
Current gravimetric technology has been widely used in the fields of exploration, underwater navigation and site investigation

... but its efficacy is limited by large measurement time and poor resolution.

The potential of the new device is to locate underground features at significant depths with a diameter to depth ratio of <<1

... e.g. a 100mm cavity at 10m depth

... which equates to a gas pipe installed by Horizontal Directional Drilling



Detection of Archaeological Residues using remote sensing Techniques (DART)

What are the best ways to employ the different sensors (*a multi-sensor approach*) for the greatest heritage return?

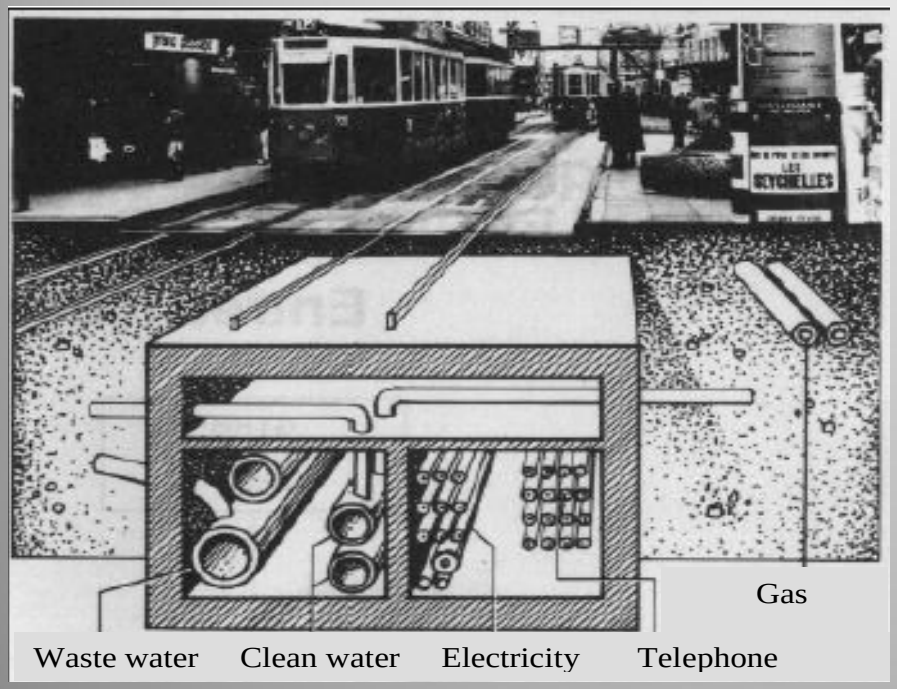
- how do we improve the use of different sensors in regional/national prospection programmes?
- what are the best conditions (e.g. environmental, seasonal, weather, crop) for deployment?

£800k from EPSRC / AHRC, led by Leeds University

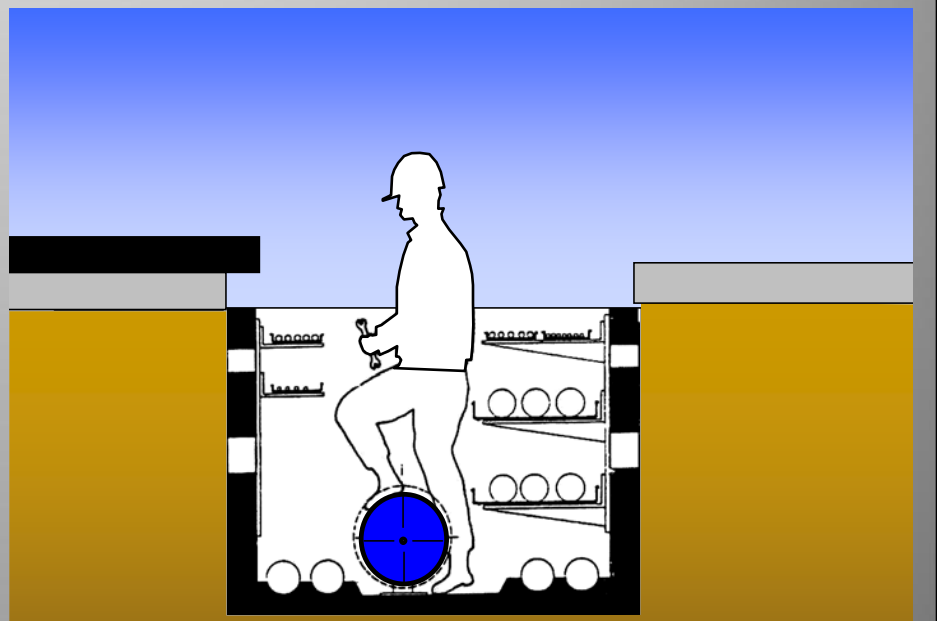
... we are adding the soils research capability, and

... a knowledge-based approach to archaeological works

Sustainable Urban Environments

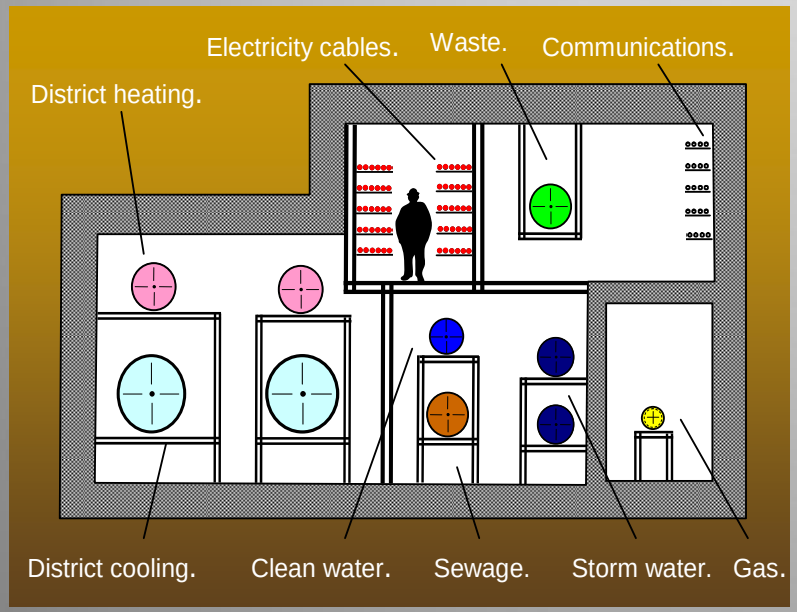


Near surface placement under tramway in Geneva (1972)

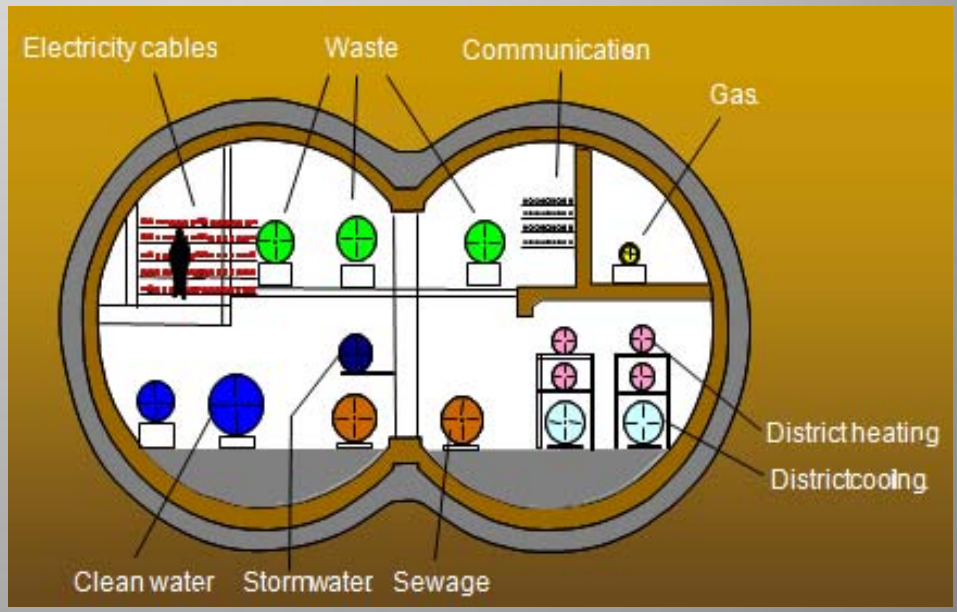


Near surface placement in pathway in Barcelona (1992)

Sustainable Urban Environments



'cut and cover' in Japan (2002)

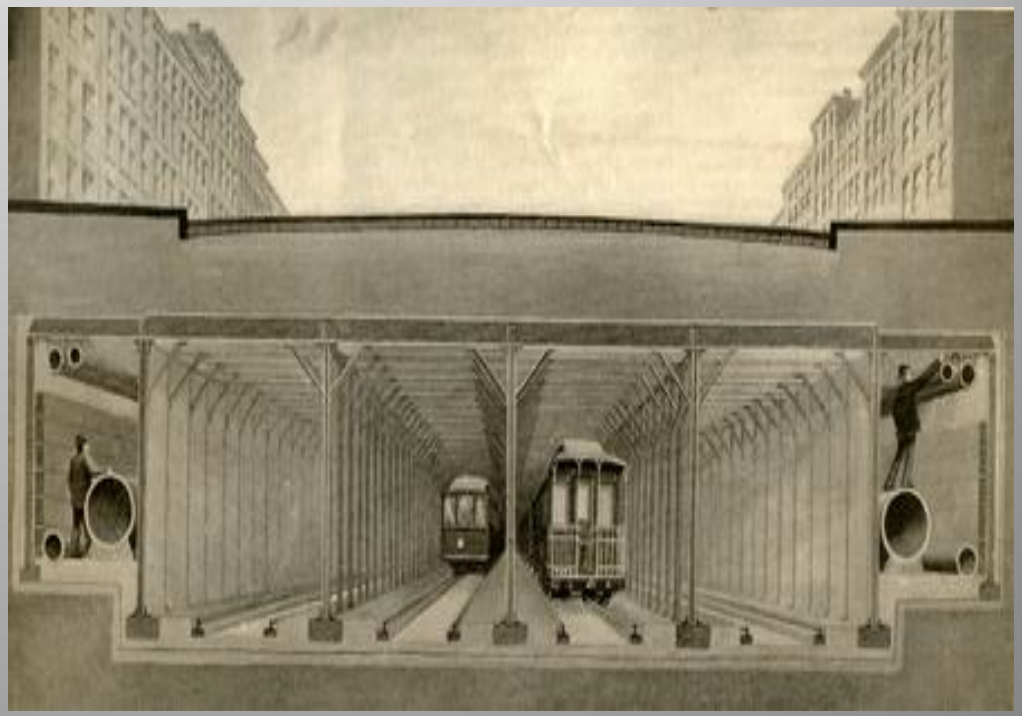


'DOT tunnelling' in Japan (2002)

Sustainable Urban Environments

The concept for alternative approaches existed over 100 years ago…

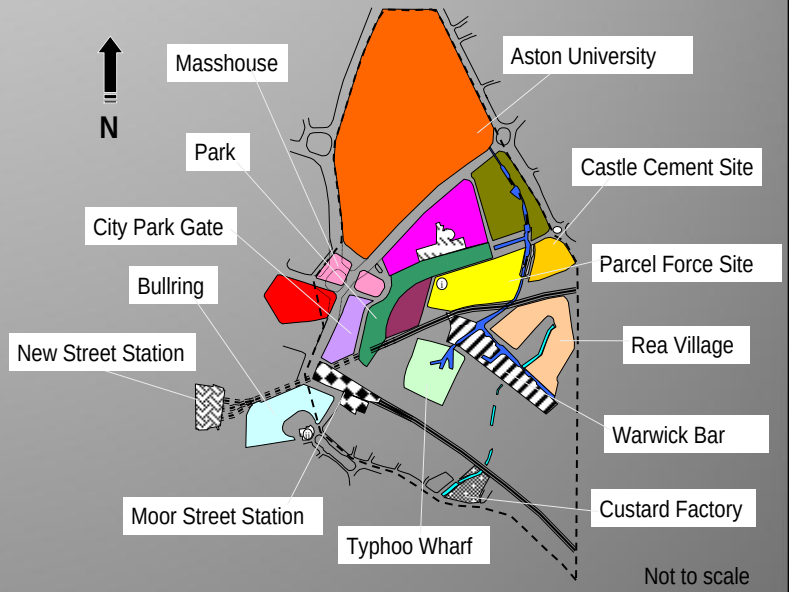
Traditional placement method in 1880s



Concept design for a multi-utility tunnel in 1901 (Scientific America)

Eastside (Birmingham, UK)

- 170 ha regeneration site
- > £6 billion estimated cost
- 15 - 20 yr regeneration project



Birmingham Eastside SUE Headlines

£1.1 million from EPSRC (2003-08) for multi-disciplinary research ... ecologists, social scientists, planners, engineers

What is 'sustainable' is determined locally: ***local conditions*** set ***local priorities***

The ***past*** and the ***present*** must be incorporated to achieve more sustainable regeneration

Early involvement in the development process is central to advancing the sustainability agenda

Individual design decisions influence the ability to meet very different sustainability objectives

Urban Futures

£3.2 million from EPSRC under SUE 2

How do we plan, design and construct for the future?

... the big debate is about *sustainability*, or *resilience*

Sustainability is about putting in place now solutions that will yield a positive rather than negative future legacy

... and we are investing our limited resources today

... we want to make sure they are good investments

The essential underlying question is:

"how sustainable are these engineering solutions?"

while the answer inevitably is:

"it depends on how the future develops"

Resilience is about maintenance of function or service in the face of change ... or bouncebackability in the face of shocks

Vision

Vision:

- To test the resilience of actions being taken today (today's 'solutions') in the name of sustainability

Method:

- Identifies a sustainability solution and its intended benefit(s)
- Identifies the necessary conditions for each benefit to be delivered
- Assesses the necessary conditions in four distinct futures:

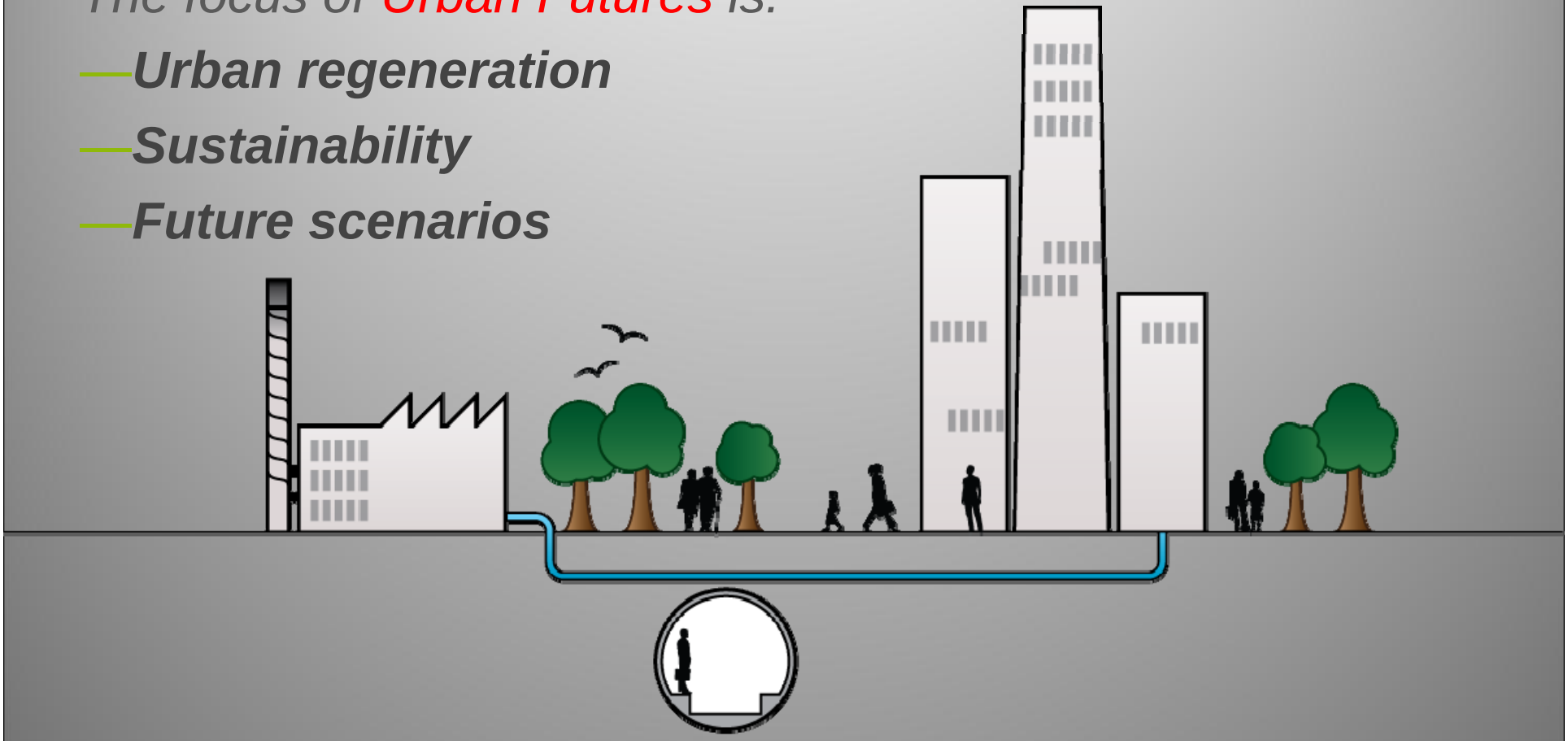
  … will the necessary conditions remain in place?

Provides analyses to determine the robustness of 'solutions' to future changes and facilitate their modification (if necessary)

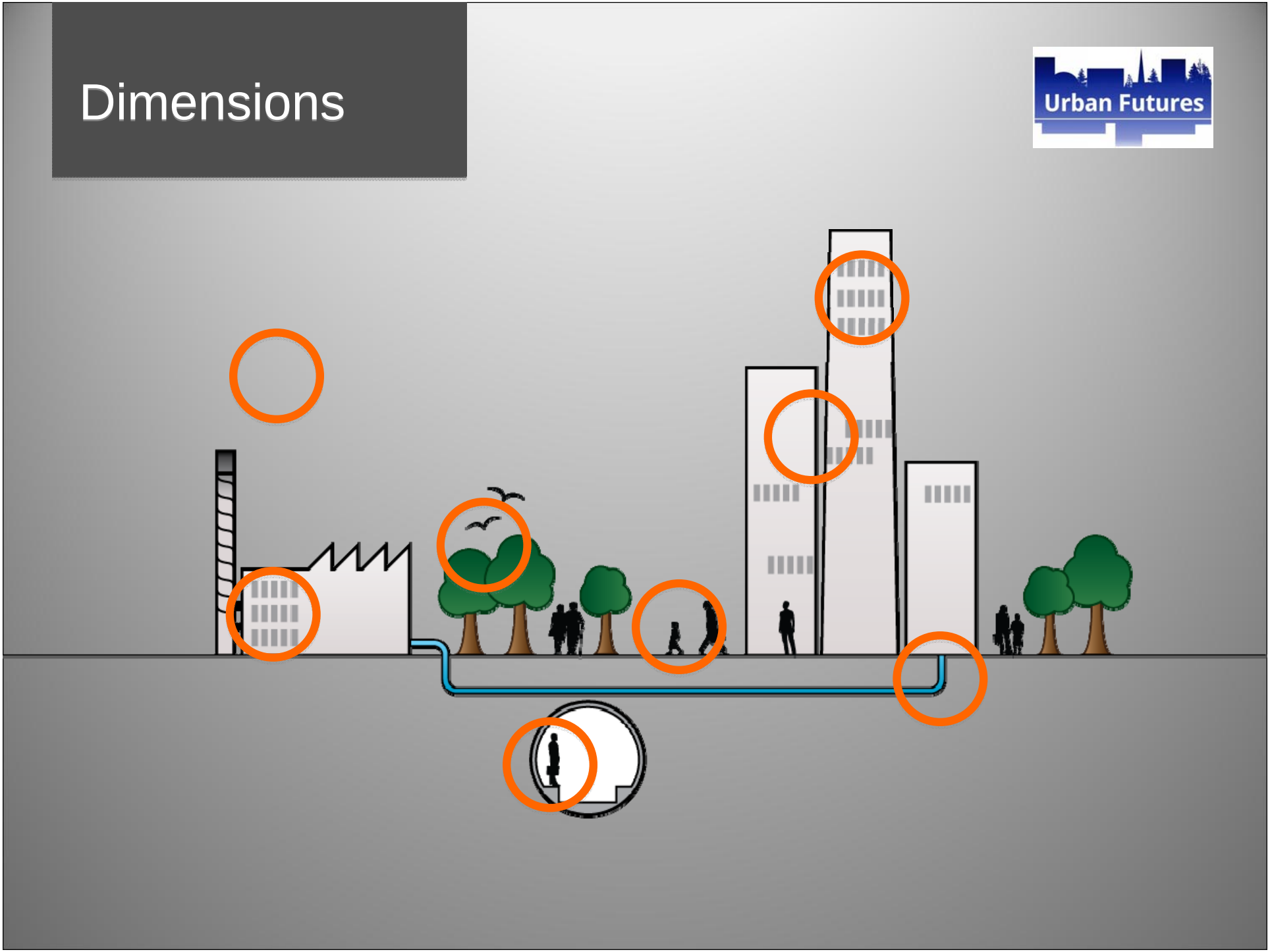
Dimensions

The focus of Urban Futures is:

- ***Urban regeneration***
- ***Sustainability***
- ***Future scenarios***

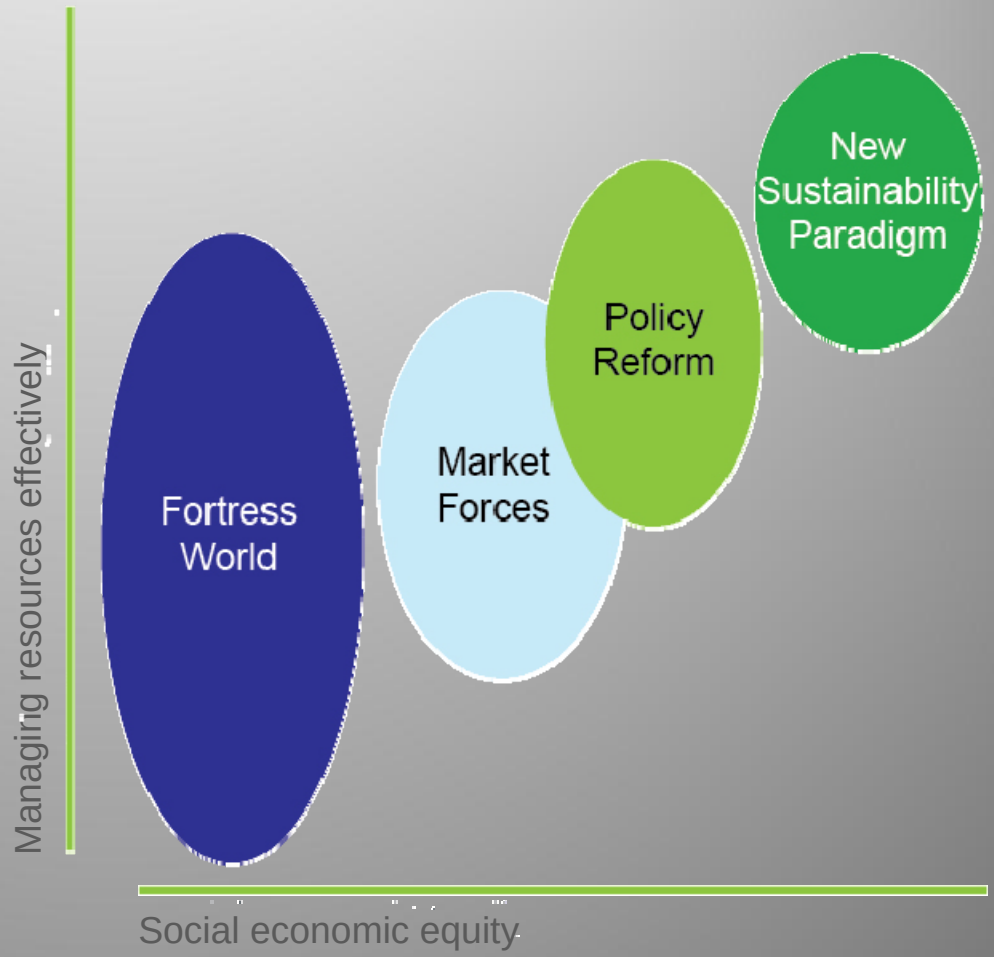


Dimensions



Developing Scenarios

- Four scenarios were chosen from the Global Scenarios Group (www.gsg.org)
- The scenarios were refined to the UK – urban scale
- Lists of characteristics were developed for each scenario



The Urban Futures Method

Solution, intended benefit

- Fortress World
- Market Forces
- Policy Reform
- New Sustainability Paradigm

The Urban Futures Method

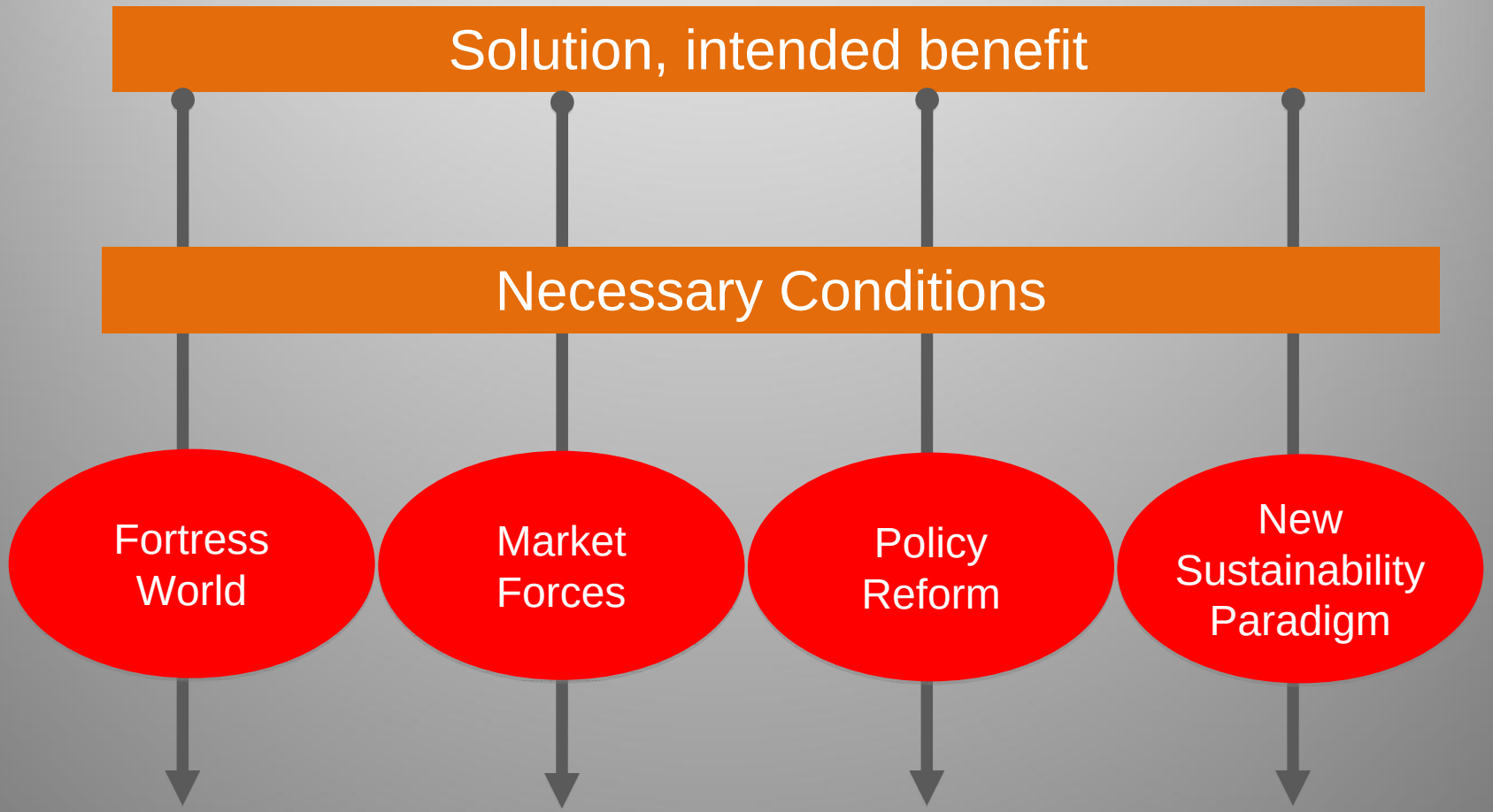
Urban Futures

Solution, intended benefit

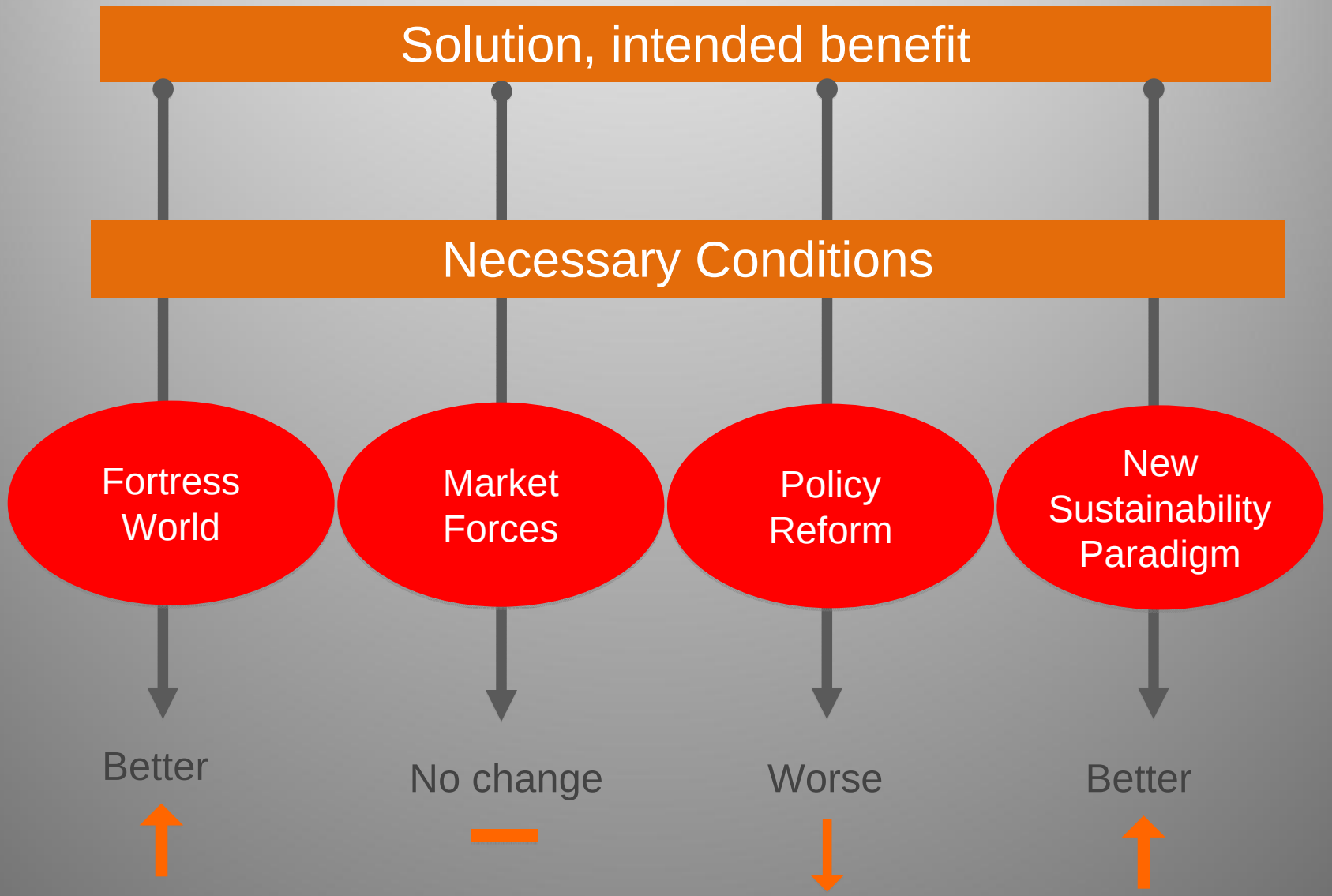
Necessary Conditions

- Fortress World
- Market Forces
- Policy Reform
- New Sustainability Paradigm

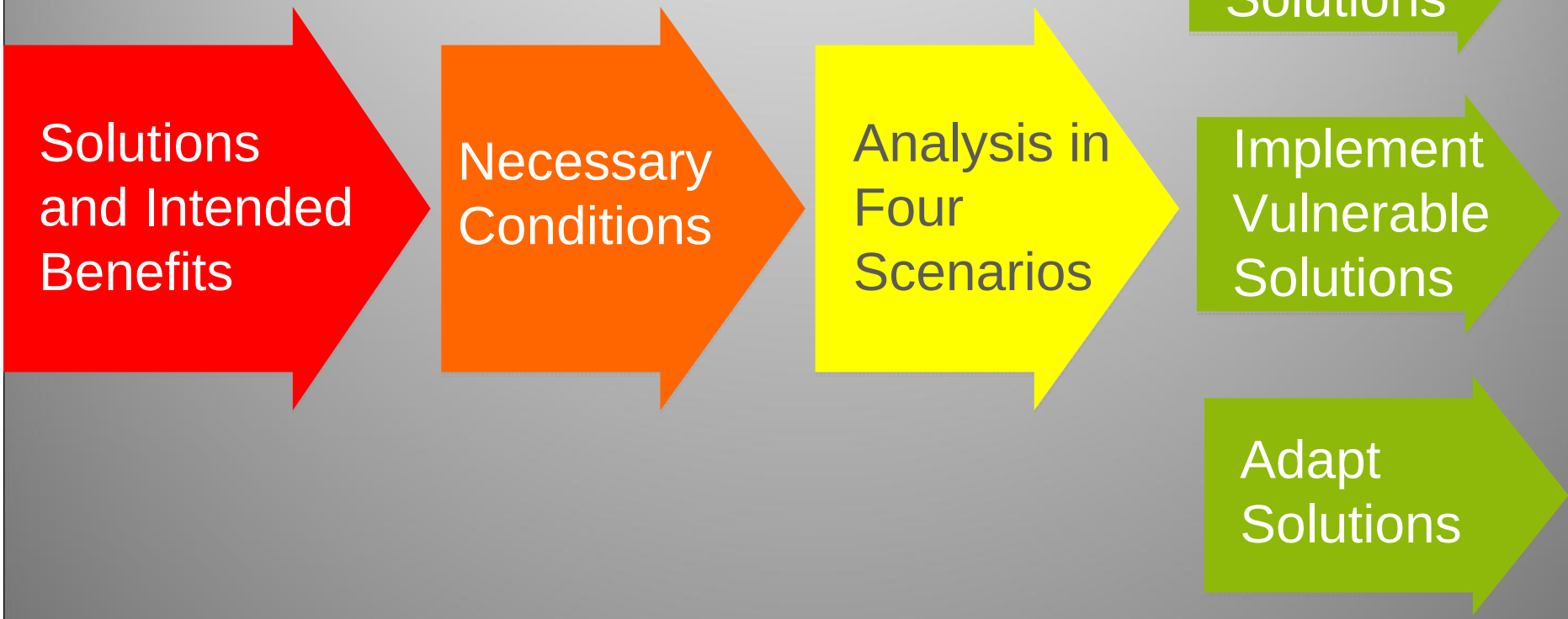
The Urban Futures Method



The Urban Futures Method



Analysis Methodology



FUTURENET

What will be the nature of the UK transport system in 2050 – physically (engineering), economically, socially *and how can its resilience be assessed, maintained and enhanced?*

London-Glasgow corridor as a basis to develop methods applicable across UK

... *Local as well as Nationally applicable*
... *Multi-modal – Rail, Road and Air*
... *Social and Economic scenarios of 2050*
... *Climate Change (UKCP09) and Extreme Weather*
... *User, Operator and Policy assessment of resilience*

Now being taken forward on an EU basis

Global Uncertainties
Security for all in a Changing World

arcc-futurenet.org

Living With Environmental Change

UNIVERSITY OF BIRMINGHAM

The University of Nottingham

Flying debris

Storms with relatively short return periods (one – two years) can cause significant damage in the urban environment. Approximately **36%** of wind related damage arises as a direct result of windborne debris.

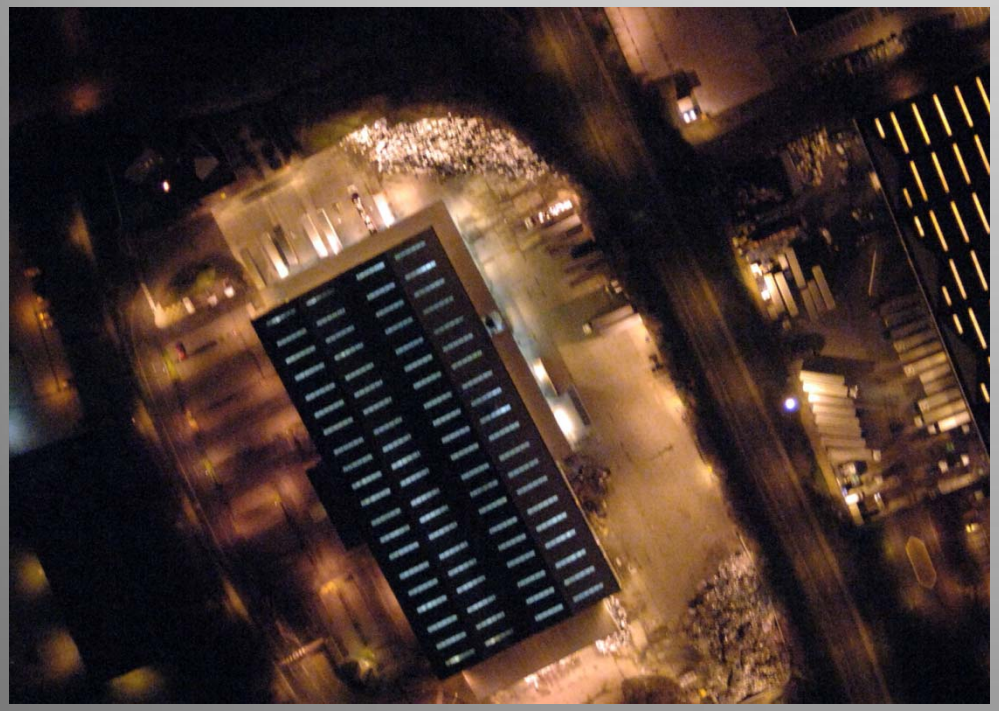
Objectives of the work are:

- to **measure** the pressure field around items of debris as they 'fly' through the air
- to **model** (analytically and numerically) the possible flight paths of wind borne debris
- to **develop** a risk based model in order to quantify the risk of debris in the urban environment

EPSRC
Engineering and Physical Sciences Research Council

Artificial Lightscapes

£100k from EPSRC to explore more intelligent city lighting
... for people and biodiversity



EPSRC
Engineering and Physical Sciences Research Council

Resilience Through Innovation

Critical Local Transport and Utility Infrastructure

- There is much emphasis on national infrastructure
  ... *we plan our service provision nationally*
- Yet recall for a moment the Severn flooding in 2007
  - *no one could have predicted the severity, or locations*
  - *flood defences were stored centrally' for deployment*
  - *yet flooded roads prevented delivery*
  - *flooded substations knocked out electricity in Tewksbury*

    ... which stopped water / sewerage pumping, and gas boilers – it compromised service provision
- What would a ***local plan*** have looked like?
- *£200k from EPSRC under the Cross-Disciplinary Feasibility Account Scheme* ... Local approaches, scaled up, might provide more sustainable and resilient solutions

Long-term Behaviour of Corroded Concrete Structures Strengthened in Shear with FRP Systems

This project aims to:
(i)increase confidence in the use of fibre reinforced polymers (FRPs) as shear reinforcement for existing concrete structures, and
(ii)facilitate the use of FRP shear strengthening systems to *enhance the capacity* and *increase the life span* of existing *road and rail concrete bridges*.

This objectives are:
To identify the *influence of corroded steel shear reinforcement* on the behaviour of FRP-strengthened members subjected to *cyclic and fatigue loading*

To evaluate the accuracy of current *design guidelines* for shear strengthening and improve their predictions

Experimental programme complemented with both numerical and analytical studies.

For further discussions please e-mail: s.m.o.h.dirar@bham.ac.uk

Sustainable Railway Track Systems

This project aims to develop sustainable railway track systems by utilising recycled concrete reinforced with fibre reinforced polymer (FRP) bars.

This objectives are:

To study the structural behaviour of *rail sleepers* made of *recycled concrete* reinforced with *corrosion-resistant FRP bars*

To investigate the use of high strength concrete to develop a new generation of robust *lightweight* rail sleepers

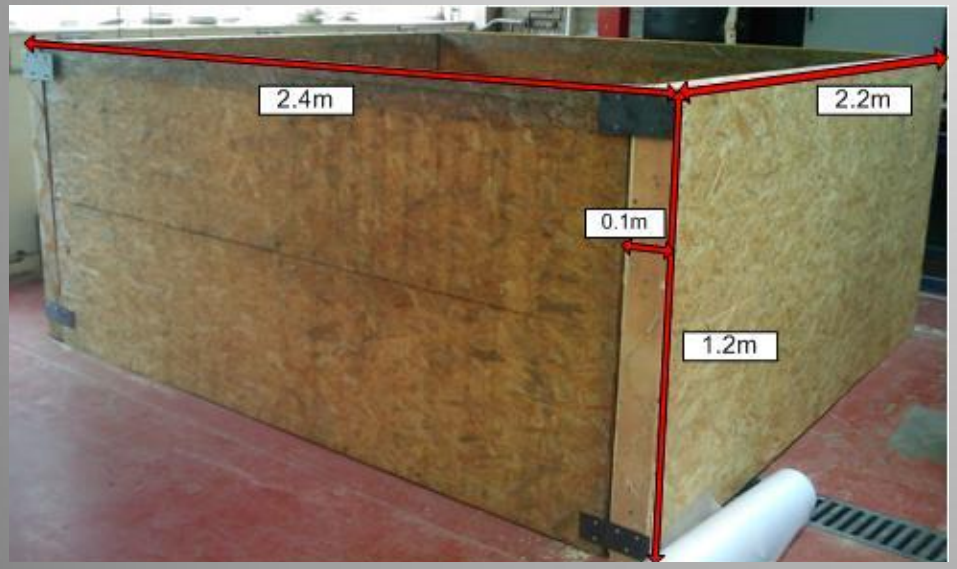
Network Rail uses about *550,000 concrete sleepers* per annum in the construction and retrofitting of new and existing lines.

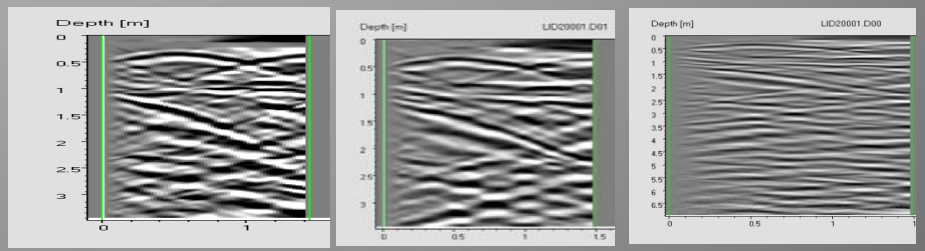
Current issues include *heavy weight* (difficulty with both transportation and installation), *corrosion of internal steel reinforcement* and *unsustainable use of aggregates*.

Static and fatigue tests on full-scale samples complemented with numerical and analytical studies.

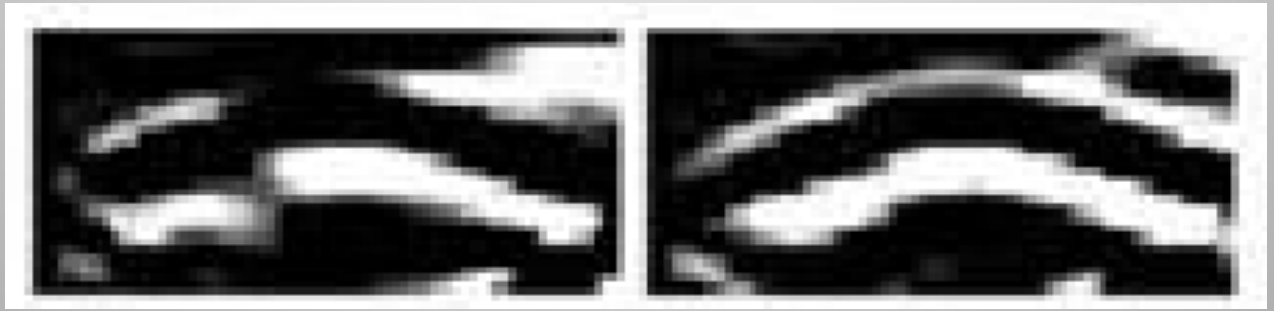
For further discussions please e-mail: s.m.o.h.dirar@bham.ac.uk

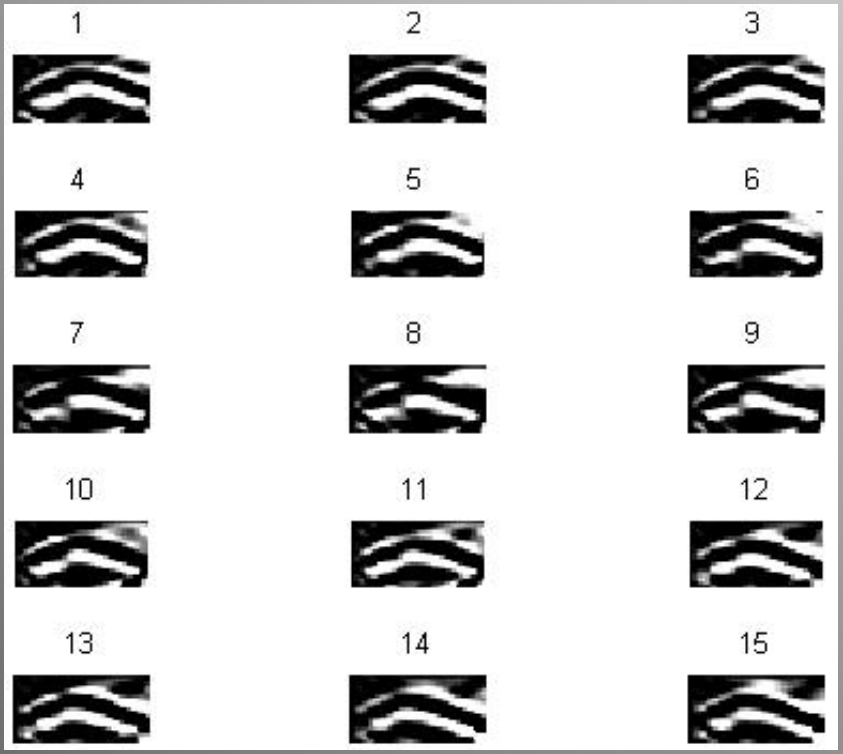
Assessing the Condition of Buried Pipes using Standard GPR

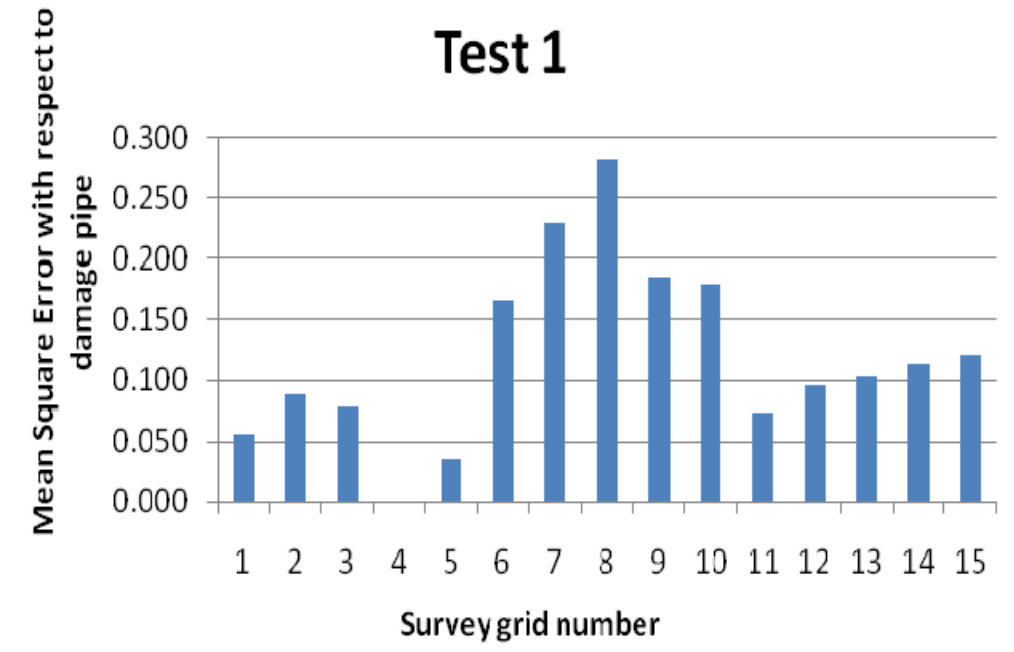




Analysis uses the signal contrast between a ‘good’ and ‘damaged’ pipe section







Conclusions

There is much activity focussed on infrastructure at Birmingham – several approaches to making our cities more sustainable, and our engineering solutions more resilient

… some question why we do the things we do

- ***Artificial Lightscapes*** *questions lighting at night*
- The ***Critical Local Transport and Utility Infrastructure*** project is exploring whether resilience can be better built in locally, and the implications for national infrastructures
- ***Flying debris*** explores the implications of extreme weather

… some provide enabling technologies

- ***Mapping the Underworld, Gravity Gradient*** *and* ***DART***
- ***Multi-utility tunnels*** *and '****Smart' pipes***
- ***FRP systems*** *for* ***concrete repair*** *and* ***railway track systems***

… some are adopting a futures approach

- ***Urban Futures*** seeks to test whether today's engineering solutions remain relevant if the future develops differently
- ***FUTURENET*** is exploring how we might travel in 2050

Conclusions

Where do we go from here?

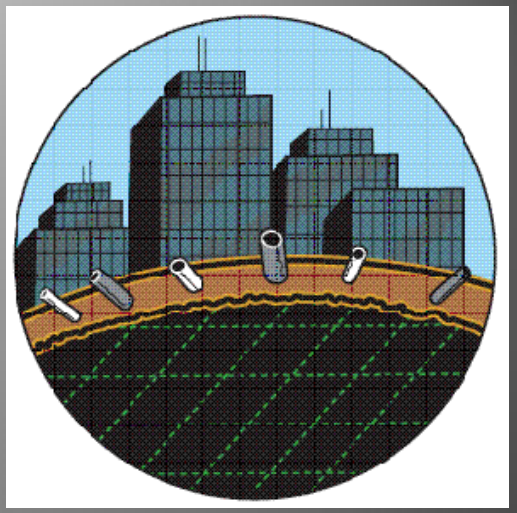
The focus will continue to explore how we make our cities more sustainable, and our engineering solutions more resilient

… *A **Programme Grant** proposal builds on much of the SUE research, yet integrates the futures thinking with quality of life, social practices and societal aspirations (UB, UCL, Southampton, Lancaster)*

… ***Mapping the Underworld** has a remit to morph into **Assessing the Underworld**, linking condition assessment of buried utility infrastructures with surface transport infrastructures (UB, Bath, Southampton, Leeds, Sheffield)*

… The ***Critical Local Transport and Utility Infrastructure*** project will yield a proposal to explore whether resilience can be better built in locally, and the implications for national infrastructures of adopting the localism agenda

Thank you for listening



Urban Futures

Resilience Through Innovation

Critical Local Transport and Utility Infrastructure