ROAD TO NET ZERO

DISCOVER
DESIGN
DELIVER

Innovations to Transform Subsurface Engineering – from Vision to Reality

Chris Rogers
University of Birmingham

www.roadtonetzero.org.uk

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UKCRIC

UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES

Inspired infrastructure for better living

A Portfolio of (Buried) Infrastructure and Urban Systems Research

Professor Chris Rogers

University of Birmingham

2nd April 2025

Urban Futures

GG TOP

Liveable Cities

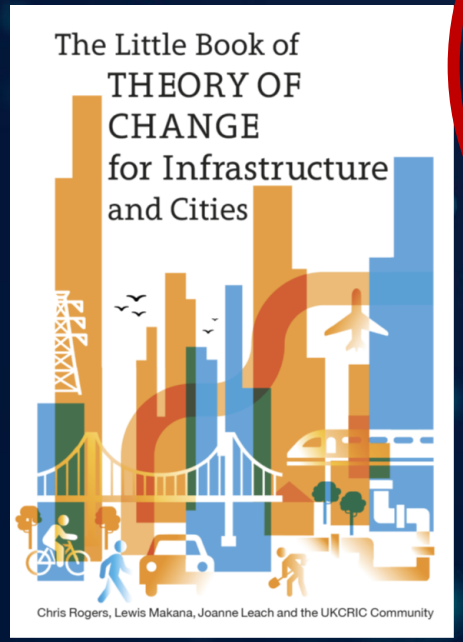
urban living Birmingham

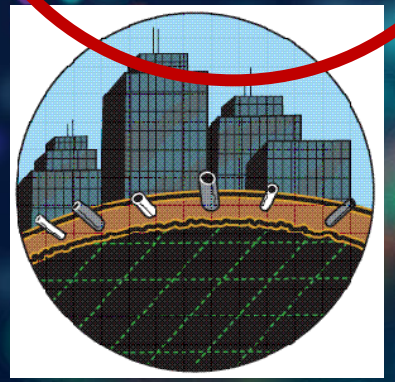
Resilience Through Innovation
Critical Local Transport and Utility Infrastructure

ROAD TO NET ZERO

ASSESSING THE UNDERWORLD

Pipebots





EPSRC

Pioneering research and skills

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Streets and the Urban Metabolism

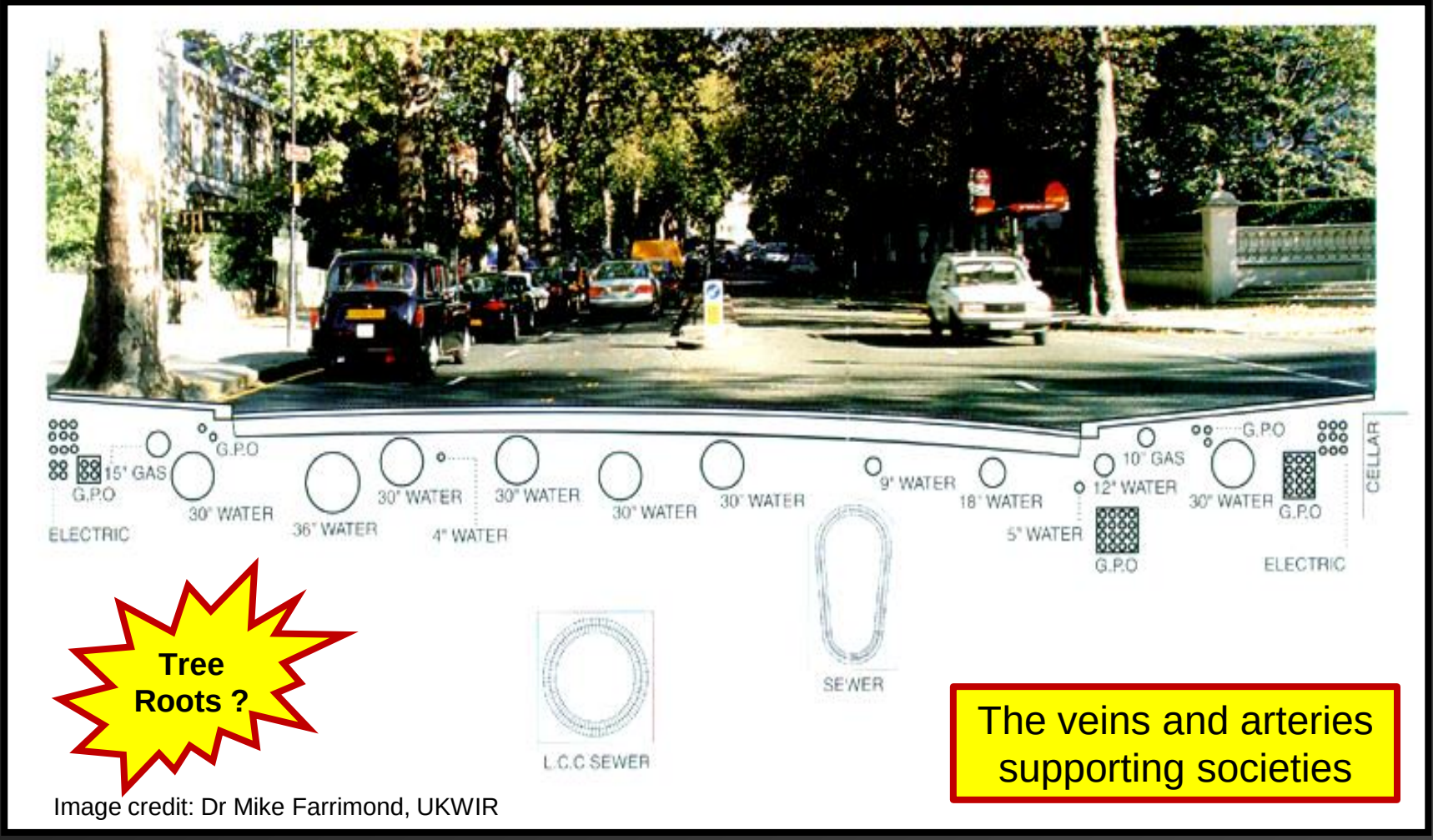

Image credit: Dr Mike Farrimond, UKWIR

The veins and arteries supporting societies

The urban metabolism – the flows facilitating urban living:

- People in vehicles
- Access to public transport
- Active travel
- Goods delivery
- Frontages to residences
- Dwell spaces, place-making
- Access to nature, flora …
  … and fauna – biodiversity
- Ventilation, pollination
- **Buried utility services … water, gas, electricity, wastewater, data, ideas**

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Streets and the Urban Metabolism

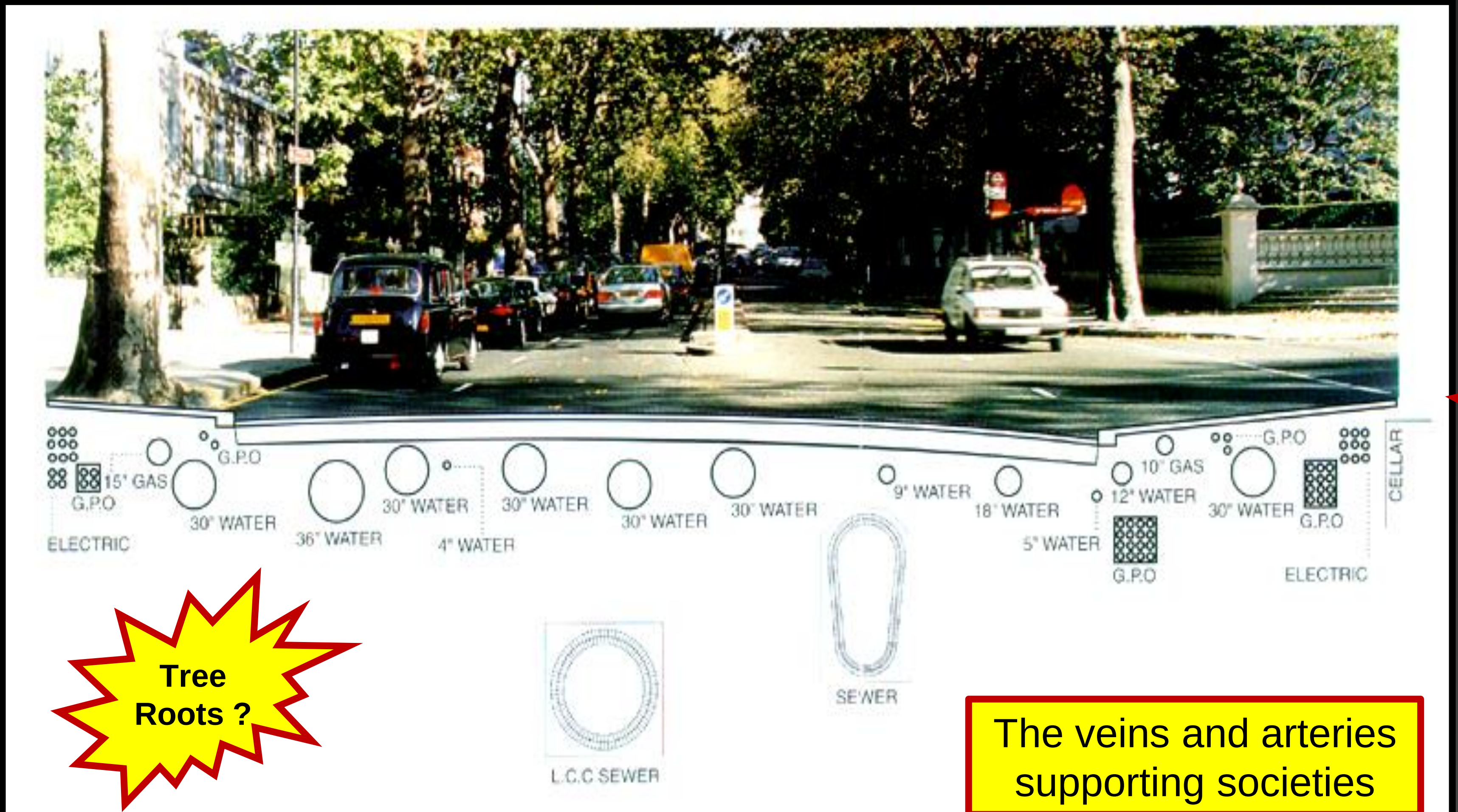

Image credit: Dr Mike Farrimond, UKWIR

The urban metabolism – the flows facilitating urban living:

- People in vehicles
- Access to pu... ...sport
- Activ...
- ...
- D... ...making
- Acce... ...ture, flora … … and fauna – biodiversity
- Ventilation, pollination
- **Buried utility services … water, gas, electricity, wastewater, data, ideas**

Only focus on the yellow / highlighted text

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Our Aspirations for Buried Infrastructure Systems

- Buried infrastructure – supports civilised life, facilitates ‘urban systems’
- Buried infrastructure – provides resources, enables things to move unrestricted
- Buried infrastructure … is there for people and society – the ultimate clients?

What do people want?

… health & wellbeing, comfort, quality of life, a thriving planet , …

Hence – efficient and effective functioning of the (buried) infrastructure systems

- That are – resilient (to contextual change), unnoticed, never ending or disrupted
- And which – augment ecological ecosystem services (hence the ‘thriving planet’)

… so how should we decide on how to carry out streetworks ?

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ASSESSING THE UNDERWORLD

Assessing the Underworld's Core Proposition

University of Bath
University of Birmingham
British Geological Survey
EPSRC Engineering and Physical Sciences Research Council
University of Leeds
Newcastle University
The University Of Sheffield.
University of Southampton
UKWIR

What is buried in, and on, the ground is controlled by the ground

… if the ground properties change, or the ground moves, the adjacent / overlying infrastructure responds accordingly

When creating, maintaining, upgrading or repurposing buried infrastructure

… we need to be informed by the ground conditions and how the ground might react to any new activity or intervention

Before we engineer in the underworld, we need to

… assess the condition of buried infrastructure

*… **assess the condition of the ground** in which it is buried*

… assess the condition of the road that overlies it

This treats the ground as an infrastructure in its own right

… with performance criteria and deterioration models

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The Consequences of Street Works

Interconnected systems result in:

- travel delays for vehicles
- travel delays for pedestrians
- travel delays for cyclists

… and for every individual thus affected there are economic and social repercussions

Street works also potentially cause

- Additional GHGs and particulates
- tree and environmental damage
- dust, noise and vibration
- Visual intrusion
- economic impacts on local businesses (sales) …

How can this harm be minimised ?

Source: Hattie Newman

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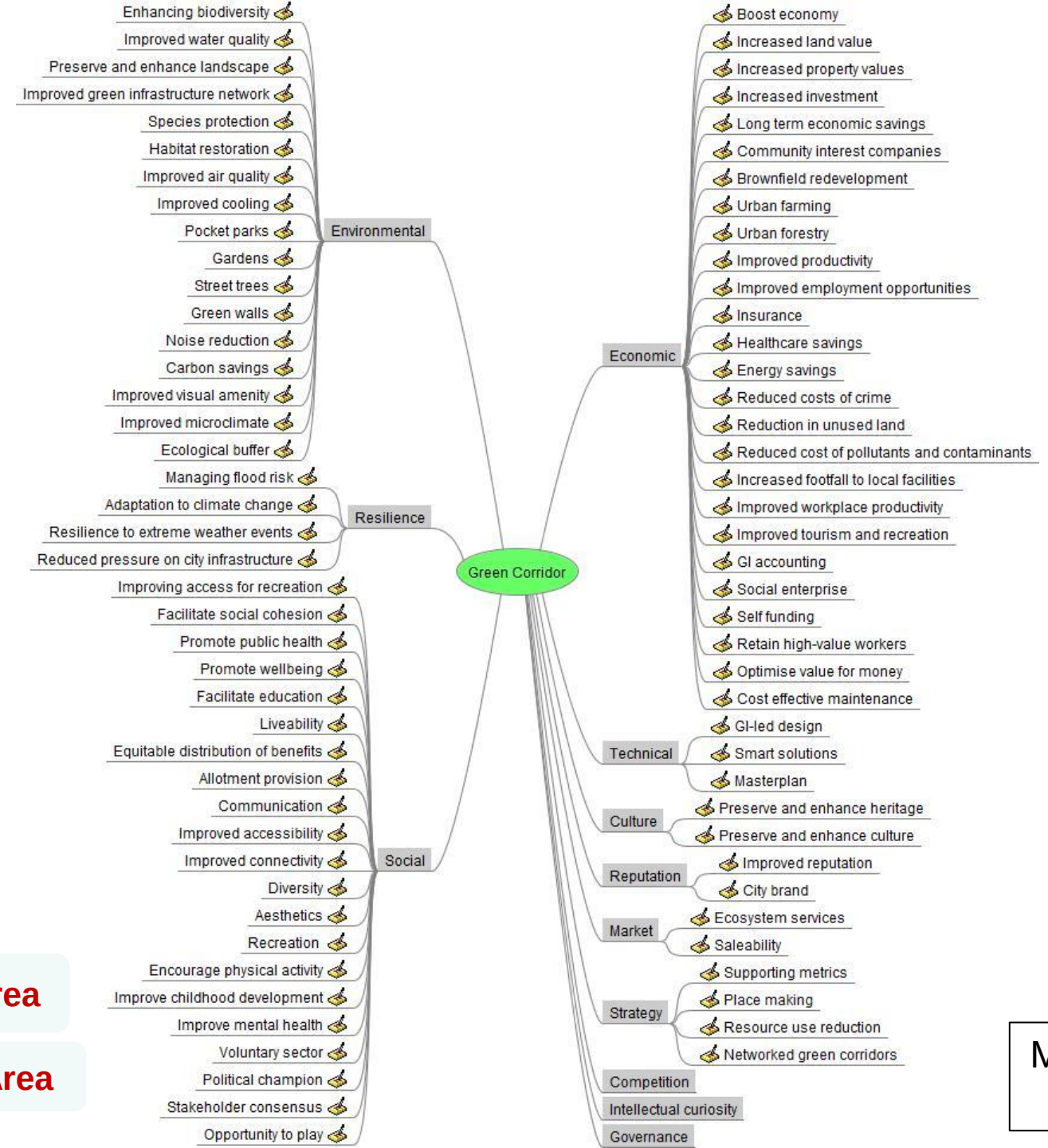
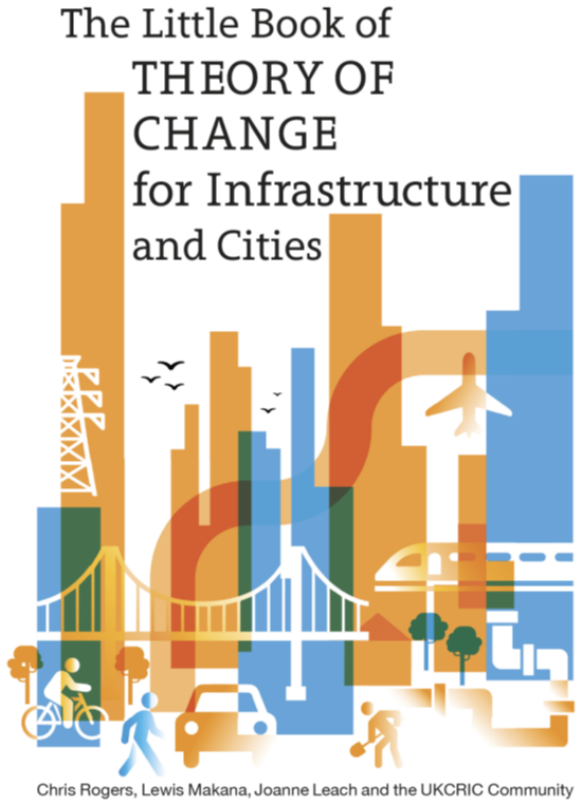
Example of a system map to identify system interdependencies

… and all stakeholders who influence or are influenced by an intervention in the system of interest





Active Travel Modes

Non-Active Travel Modes

Surrounding Residential Area

Surrounding Commercial Area

Map created by Chris Bouch
University of Birmingham

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Assessing the Consequences of Street Works

We are creating a comprehensive impact calculator that accounts for:

- Carbon emissions due to the works
- Waste resulting from the works
- Noise, dust and vibration caused by the works
- Accidents on or beyond the site due to the works
- Impacts on the natural environment
- Compromised air quality
- Traffic delays and diversions due to the works
  - This causes additional emissions, and
  - exacerbates many of the other consequences listed above

… and integrates them into an optioneering tool to aid decision-making

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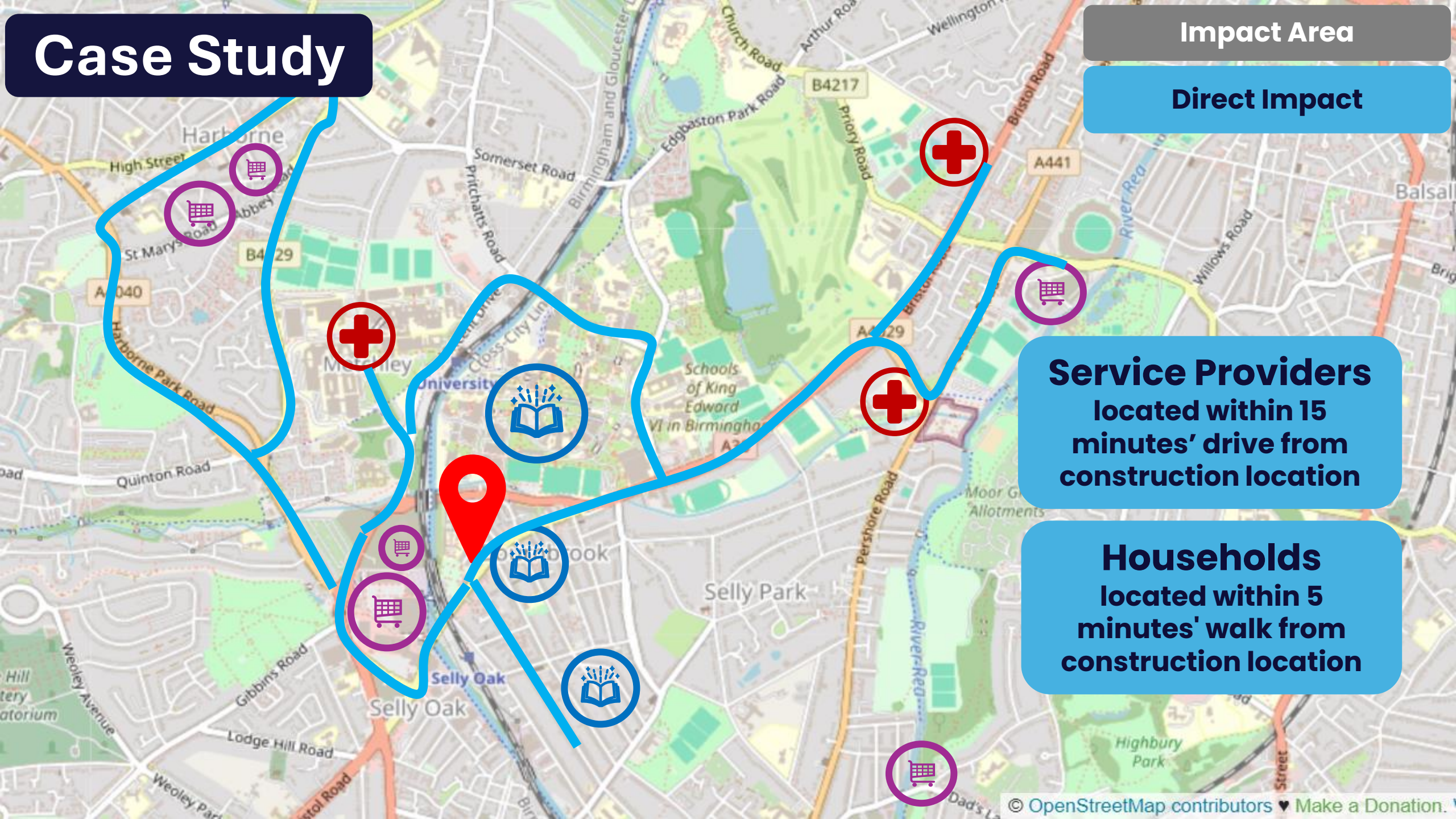
Case Study


Impact Area
Direct Impact
Service Providers
located within 15 minutes' drive from construction location
Households
located within 5 minutes' walk from construction location
Harborne
High Street
Somerset Road
Pritchatts Road
Edgbaston Park Road
Church Road
Arthur Road
Wellington
B4217
Priory Road
Bristol Road
A441
River Rea
Willows Road
Balsall
St Mary's Road
Abbey Road
B4129
Harborne Park Road
Quinton Road
Selly Park
Selly Oak
Gibbins Road
Lodge Hill Road
Weoley Avenue
Pershore Road
Highbury Park
Allotments
Schools of King Edward VI in Birmingham
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Search Google Maps
560 B384
Birmingham, England
Google Street View
Jun 2024
See more dates
1
in dBs
~£2,577
(illegal?)
2
~£3,732
3
~£4,976
6
~£62
Consequences
(approximately) total
~ £67,613
excluding
accident cost (5),
traffic delay (8), and
transportation
vulnerability (9)
7
~£53,838
8
minutes
~£XXXX
9
~£XXXX
Search Google Maps
547 Bristol Rd
Birmingham, England
Google Street View
Jun 2024
See more dates
4
~£2,488
5
~£XXX million
per accident
A narrative will accompany
the calculated values
Jarratt Hall
Goose, The
OVI, Selly Oak
Mr Egg
Recently viewed
Typical traffic
Fast
Slow
Monday, 17:50
08:00
12:00
16:00
20:00

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Design Options for Street Works

There are four essential design options:

- Trenching (or open-cut excavations)
  - Routinely used – socially intrusive , occupies much road space
- Minimum Dig Technologies
  - Involves ‘keyhole surgery’, with downhole tools and vacuum excavation
- Trenchless Technologies
  - Pipe repair, relining, refurbishment / upgrading / upsizing, new installations
  - These are mature technologies catering for all pipeline needs
- Robotics and AI
  - The next generation: autonomous inspection and repair

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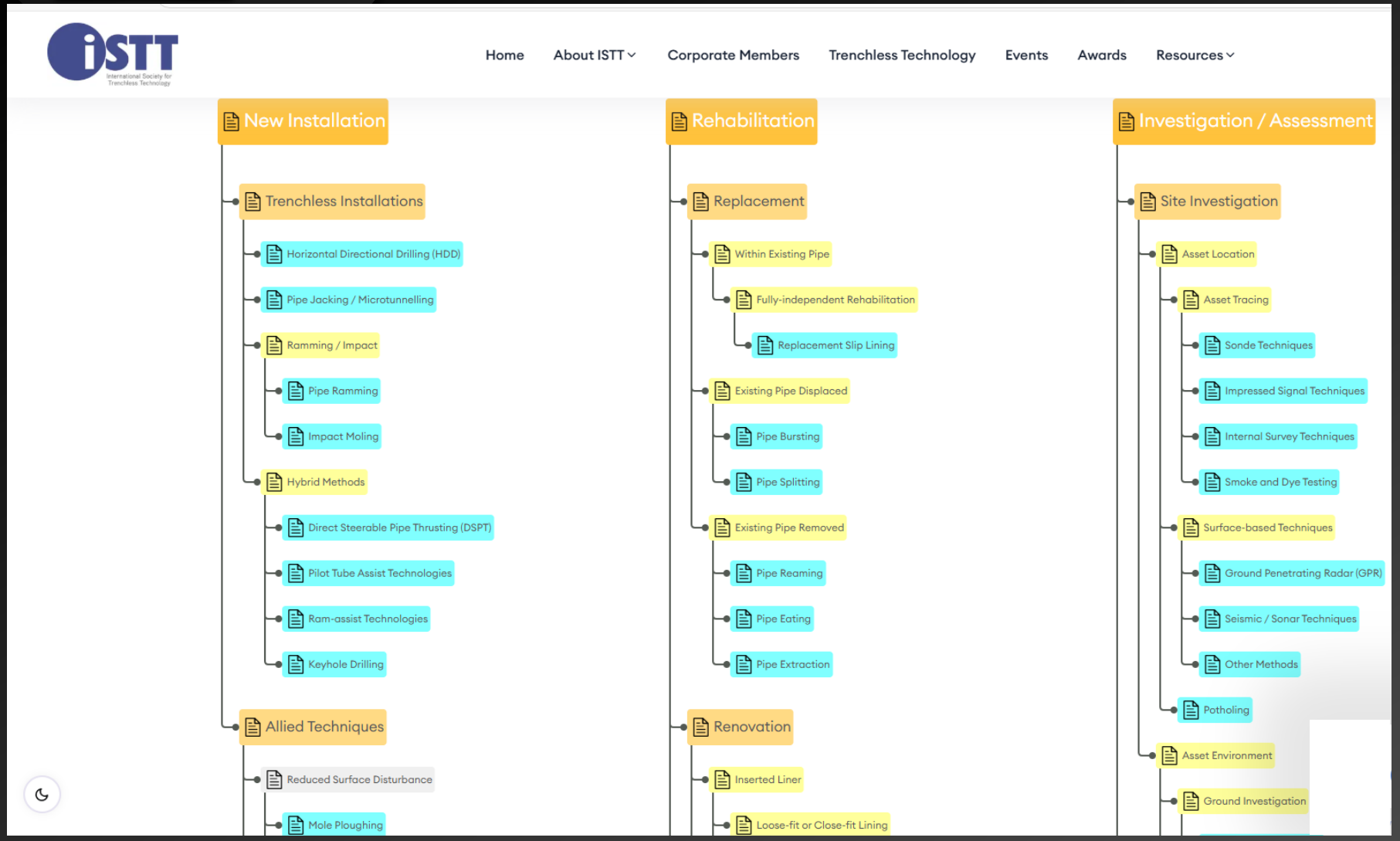
Trenchless Technology Design Options



A screenshot from the International Society for Trenchless Technology website:

- 11 generic options for new installation
- 25 generic options for rehabilitation
- 49 generic options for pipeline investigation and assessment
- Each links to detailed descriptions and practical guidance

… all tried and tested

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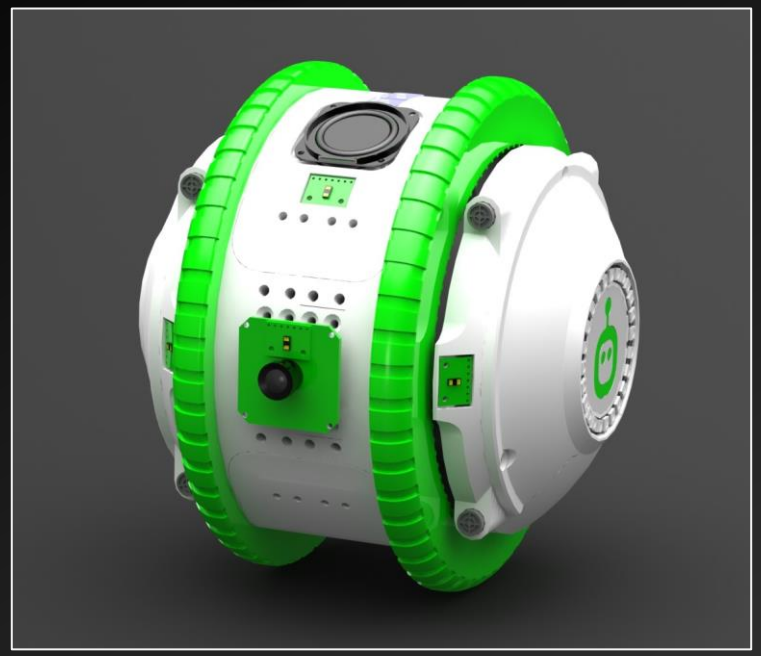
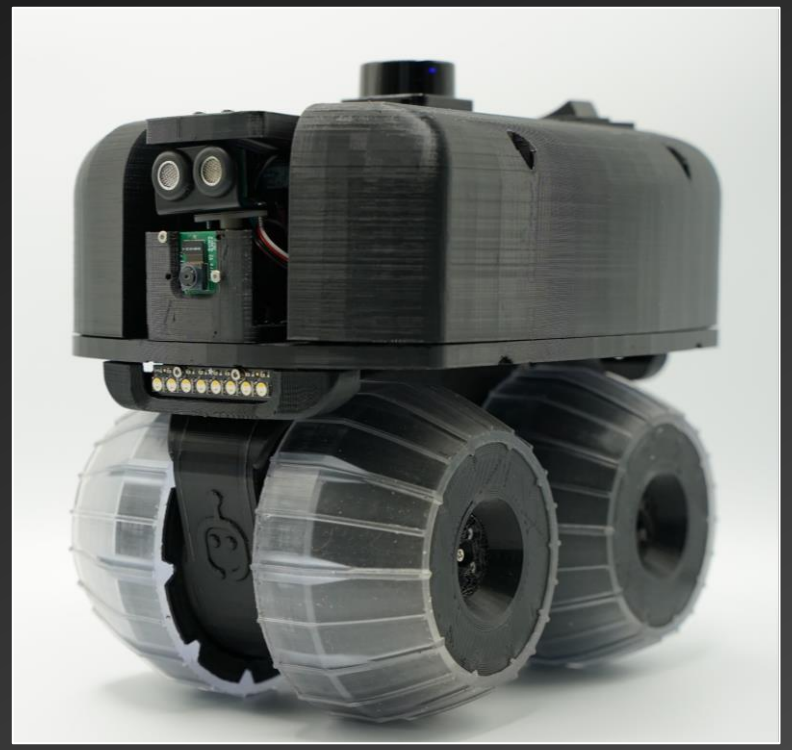
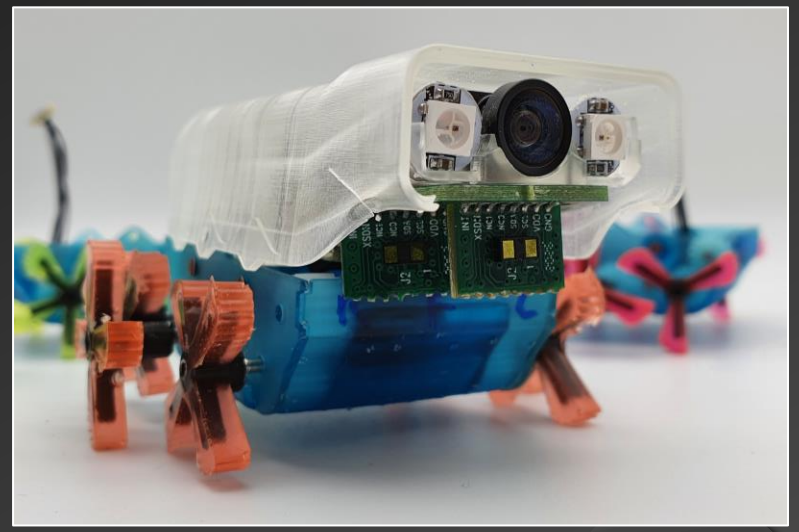
Pipebots for Live Condition Assessment







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Pipebots for Live Condition Assessment

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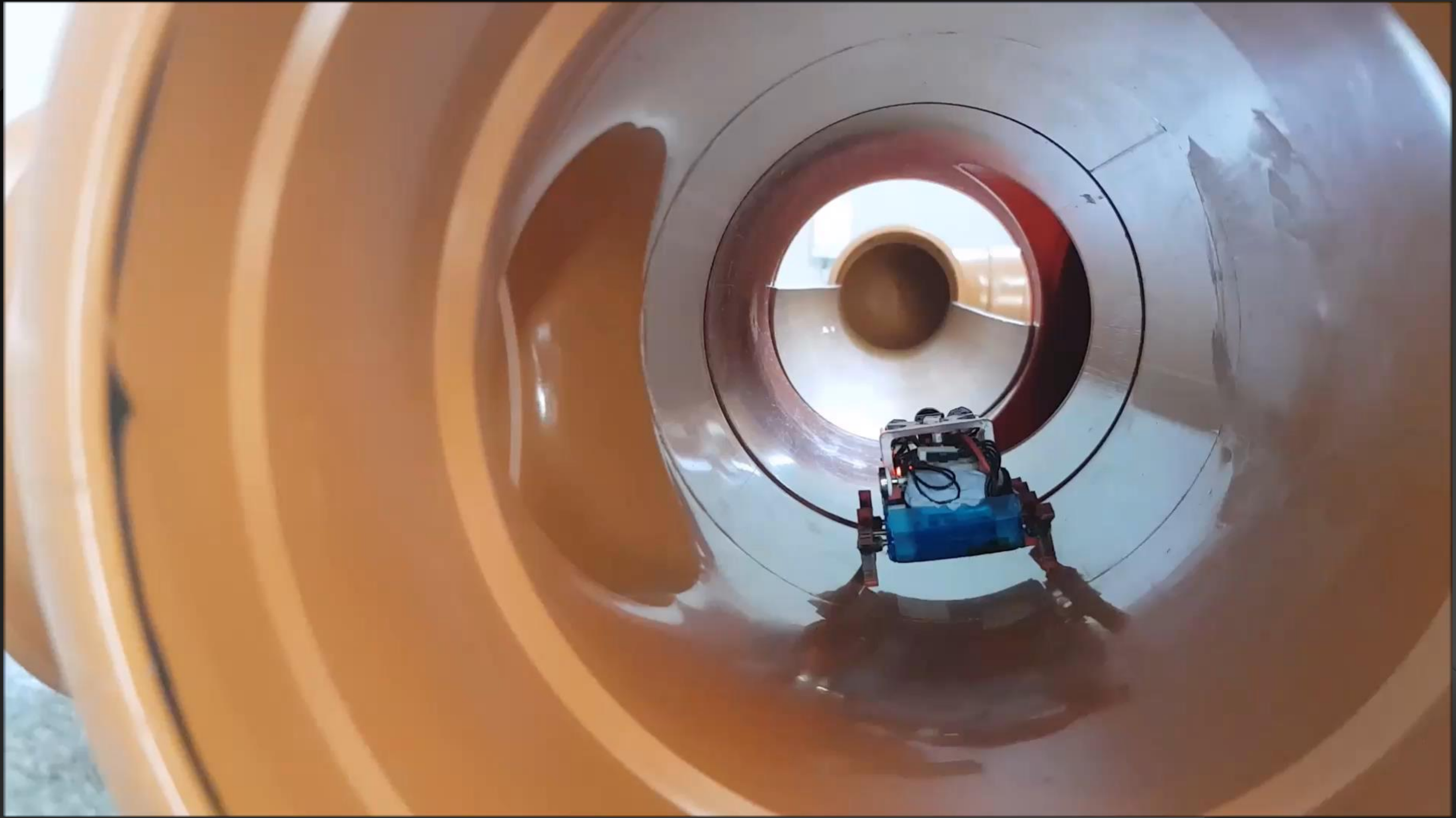

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Pipebots timeline

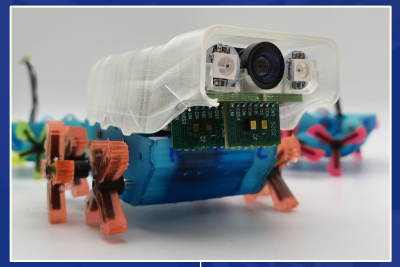
Grant started
March 2019

Launch event
November 2019

21.02.20
Trademark
Pipebots

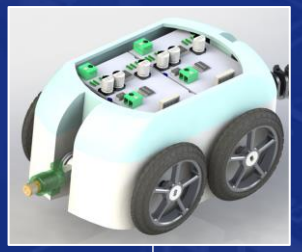
Sprintbot

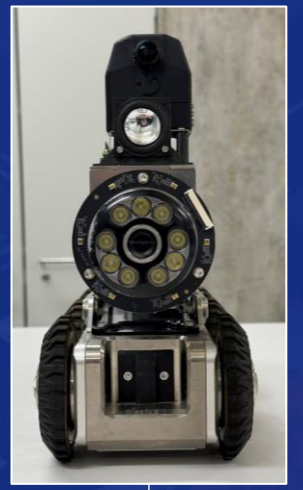
December 2020

Joey

September 2021

Skatebot Mk1

June 2023

Kanga

January 2024

Moving towards commercial robotics

May 2024

Technology adoption

underpinning science – 96 research papers

Sensing → Control → Navigation and mapping → Communication → Data analytics

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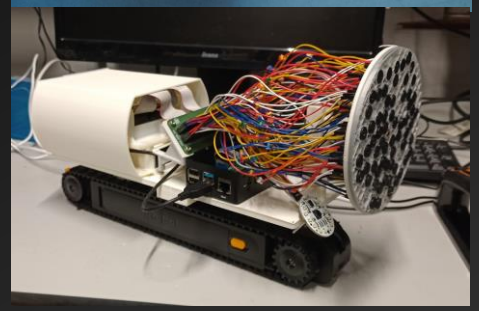
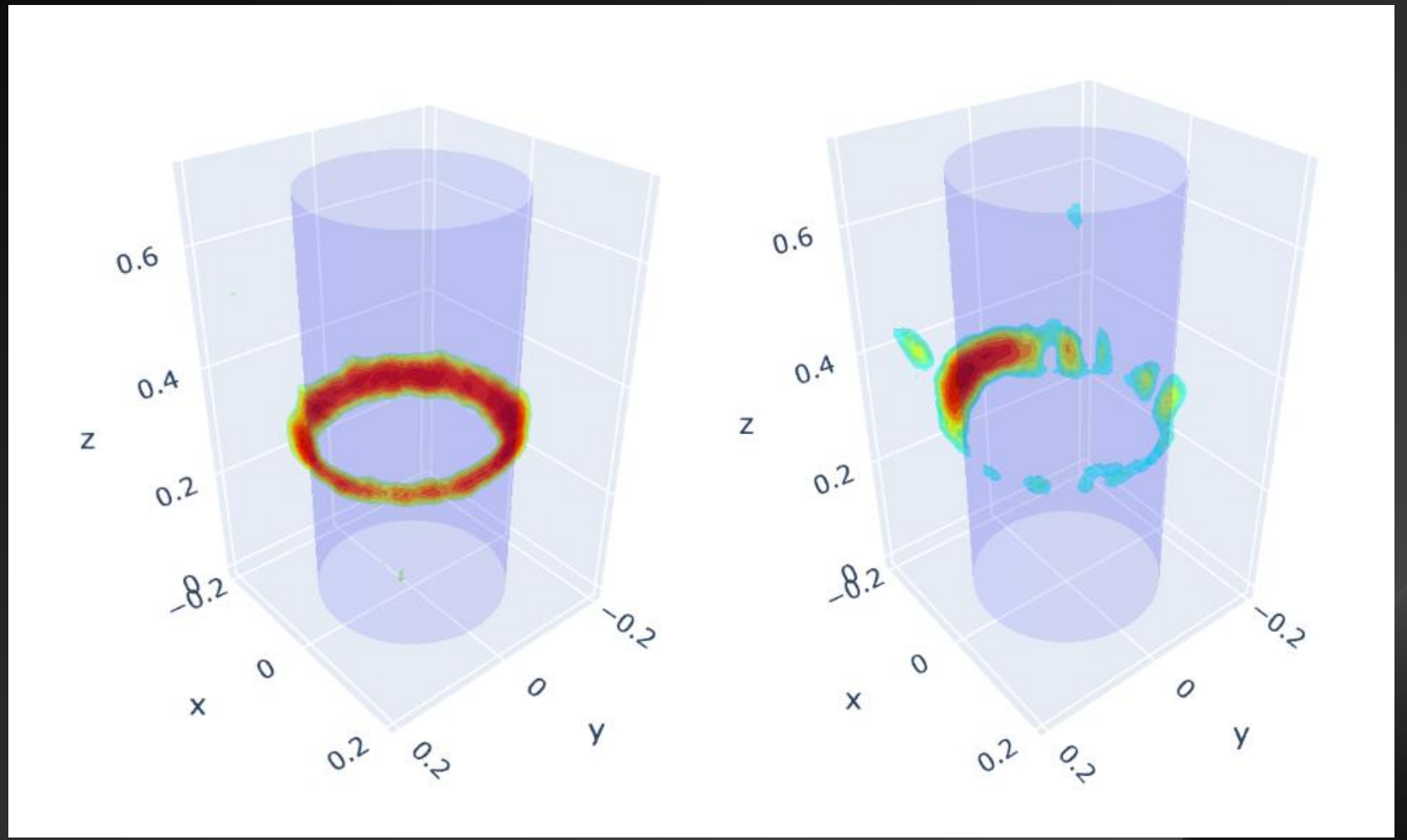
Pipebots – Ultrasonic Testing





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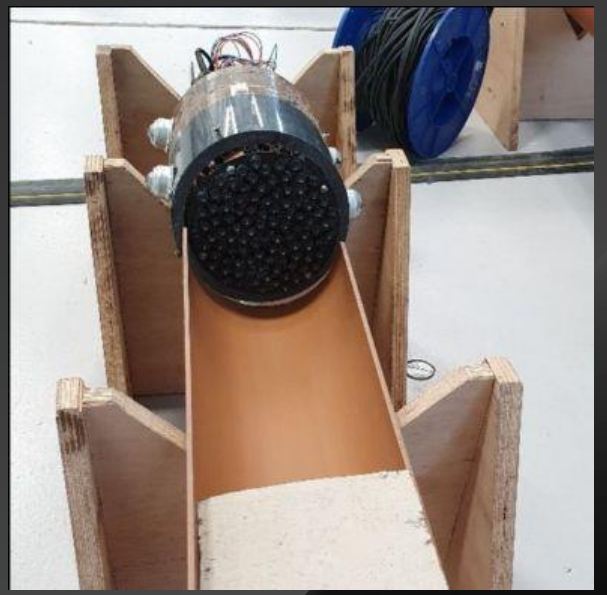
Pipebots – Prototype Trials



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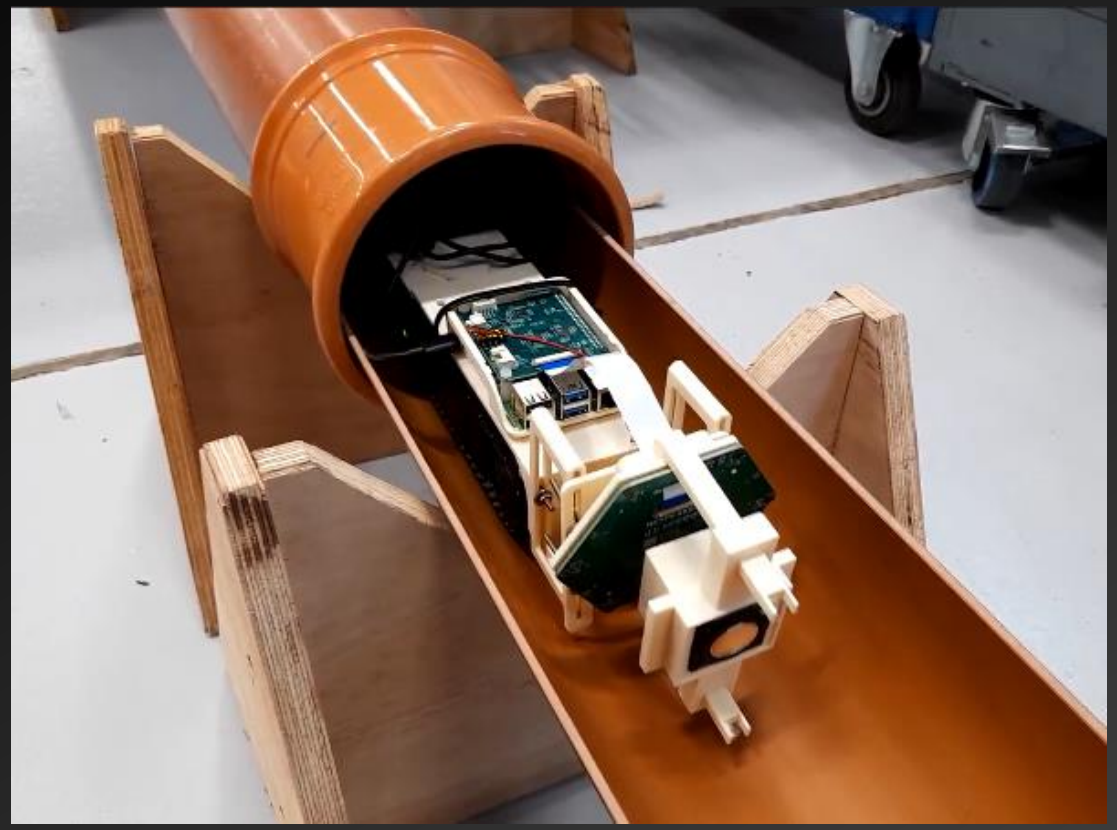
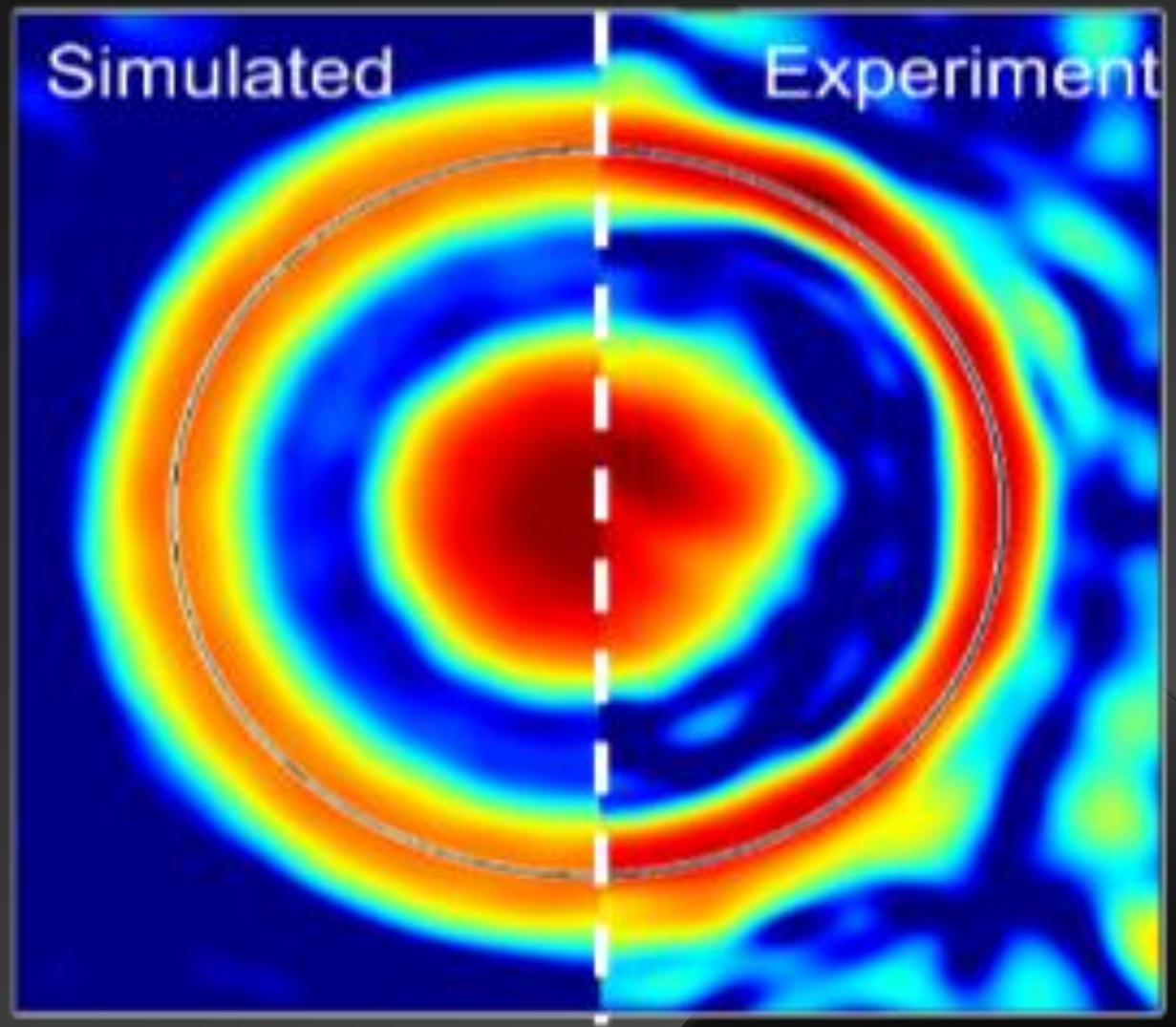
Pipebots – Prototype Trials





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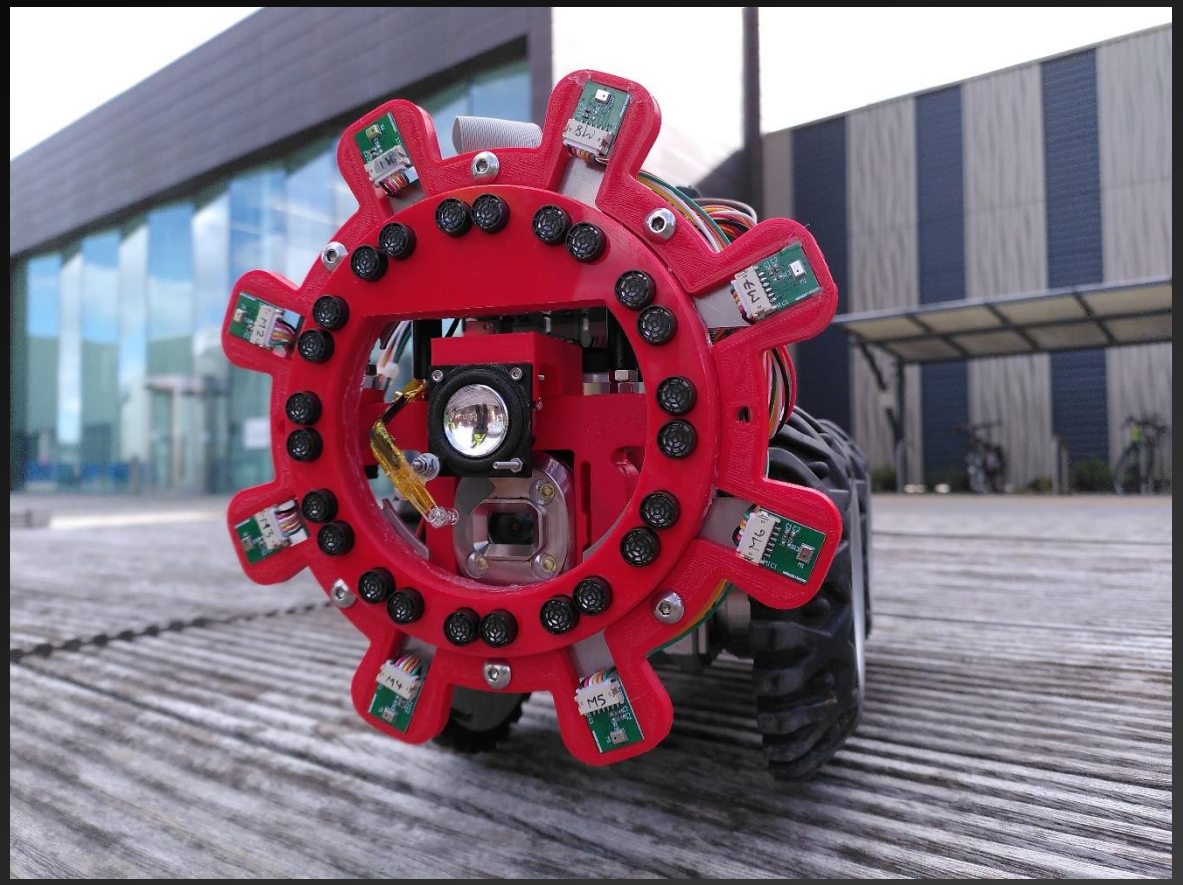

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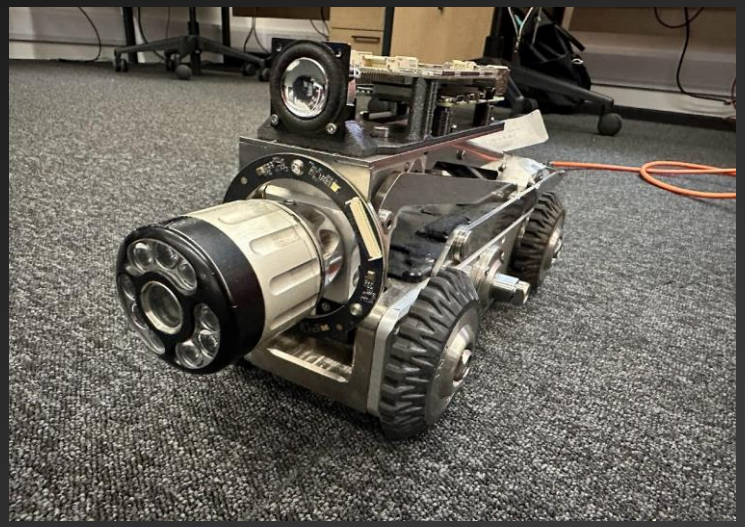
Pipebots – Higher-TRL Developments



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National Buried Infrastructure Facility

A facility for testing buried pipes and tunnels at or near full scale

National Buried Infrastructure Facility

UKCRIC

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Conclusions

We must seek to deliver greatest value when carrying out street works:

- to society and people (the 'one customer' of utility services & urban systems)
- to the planet, by protecting and enhancing the ecosystem services it provides
- with sustainability and resilience in mind (hence the move to Net Zero)

We can achieve this by:

- treating the ground as an ecosystem service provider and 'an infrastructure'
- creating an 'all consequences' street works optioneering tool (Road to Net Zero)

We must protect (and enhance) the value of our streets

We must protect our planet and the ecosystem services it provides

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Conclusions

We must seek to deliver greatest value when carrying out street works:

- to society and people (the 'one customer' of utility services & urban systems)
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We can achieve this by:

- treating the ground as an ecosystem service provider and 'an infrastructure'
- creating an 'all consequences' street works optioneering tool (Road to Net Zero)

- ***applying a theory and practice of change***
- ***researching robotics and automated systems*** (Pipebots, maybe Fixbots)
- ***trialling innovations in the UKCRIC National Buried Infrastructure Facility***

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