Understanding the interfaces of transport infrastructure and its environment: how the past explains the present, and the future

Presented by:

Nathan Darroch
at 5ES, Stratford,
as part of the
TfL Engineering
Lunchtime Learning talks.

A view of the UUMI forming cutting at Porchester Terrace, Bayswater, London.
Source: Nathan Darroch.

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Who am I?

- 34 years of personal study of transport development, use, and its effects;
- 18 years working full time in public transport in London:
  - 2 years bus driving in Twickenham; Kingston; and Hammersmith areas;
  - 5 years tram driving in Croydon;
  - (nearly) 12 years within London Underground/TfL;
    - Reviewing and responding to asset location enquiries;
    - Reviewing and commenting on planning applications;
    - Undertaking research in to the legal, historical, and engineering interfaces of transport infrastructure and its environment;
    - Advising TfL and its interfacing stakeholders on asset ownership, rights and responsibilities.

- Graduate Certificate – *Railway Studies and Transport History.*
  - *University of York (Distance Learning), Sep 2007 – Sep 2009.*
- *Master of Arts - Railway Studies by research.*
  - *University of York (Part Time), Sep 2010 – Sep 2012.*
- *Doctor of Philosophy - Transport Studies.*
  - *University of Aberdeen (Part Time), 2014 –2019.*

My thesis

Title: *Towards an understanding of the complex relationship between underground urban space and its environment, with particular focus on urban underground metro infrastructure in London.*

Aim: The creation and testing of a research methodology for the identification and clarification of interfaces between transport infrastructure and its environment.

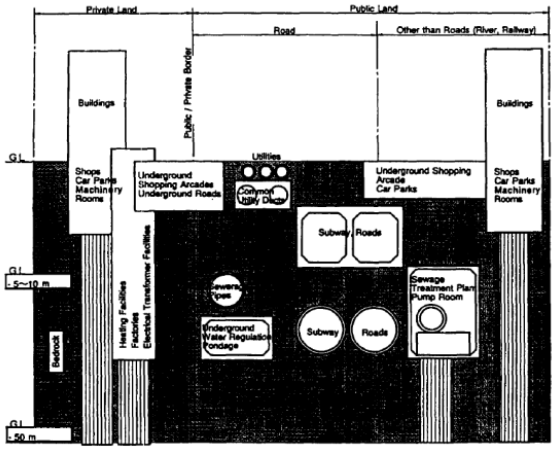
Outputs: The development of -

1. a conceptual framework and ancillary components to enable a standardised approach to the analysis of the interfaces between transport infrastructure and its environment;
2. (*with Francine Fuller and Michael Bobrowicz*) **AIR** (Asset Interface Register) a process of evidence based, data recording, verification, validation, and publication;
3. stimulation of further academic and professional discussion and analysis of the interfaces between transport infrastructure and its environment, internationally.

Why is it important to understand how the past explains the future?

Urbanisation and densification

New York, US



Potential uses for Urban Underground Space in Japan.
Source: International Tunnelling Association, 2000

Sao Paulo, Brazil

Central China's mega-city Wuhan has started the construction of the country's largest "underground city," as more cities look to underground space as land resources become scarce.
Source: Hubei, 2015

Why is it important to understand how the past explains the future?
Metro construction

"Metros are of critical importance for mobility, as societies are becoming ever more urbanised. At the end of 2017, there were metros in 182 cities in 56 countries, carrying on average a total of 168 million passengers per day. 75 new metros have opened since the year 2000 (+70%). This massive growth is to be credited largely to developments in a few countries in Asia."

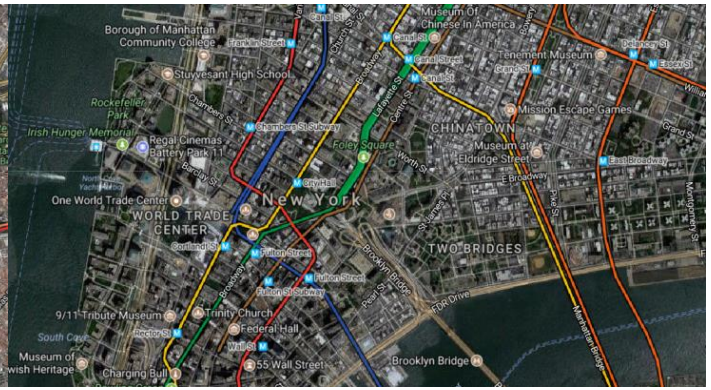
"*In 2017, the 178 metro systems accounted for a total annual ridership of 53,768 million passengers. In the last six years, annual metro ridership grew globally by 8,716 million passengers (+19.5%)*".

Source: UITP, 2014.

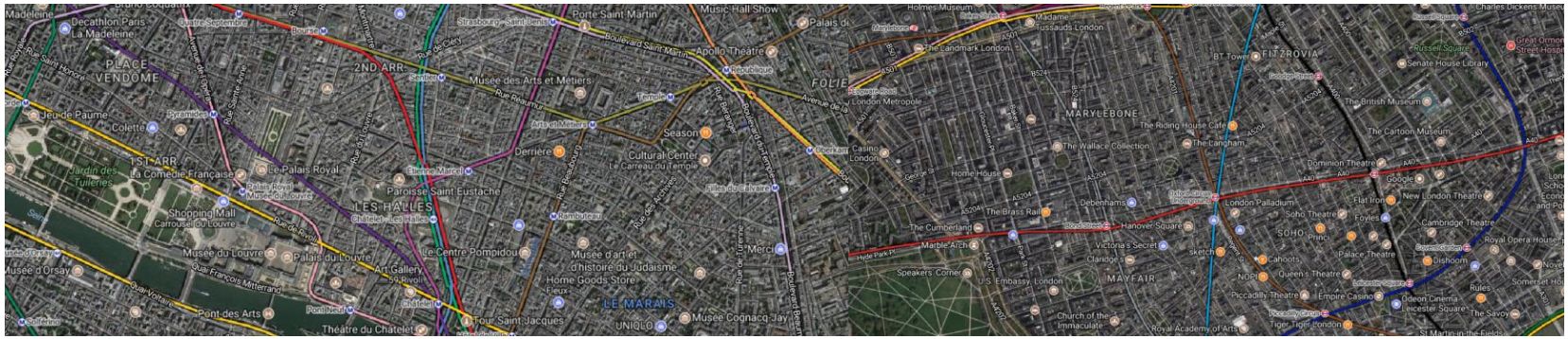
Why is it important to understand how the past explains the future?

The construction and presence of urban metro systems increases the interfaces within densifying urban environments...

Sao Paulo, Brazil



New York, US

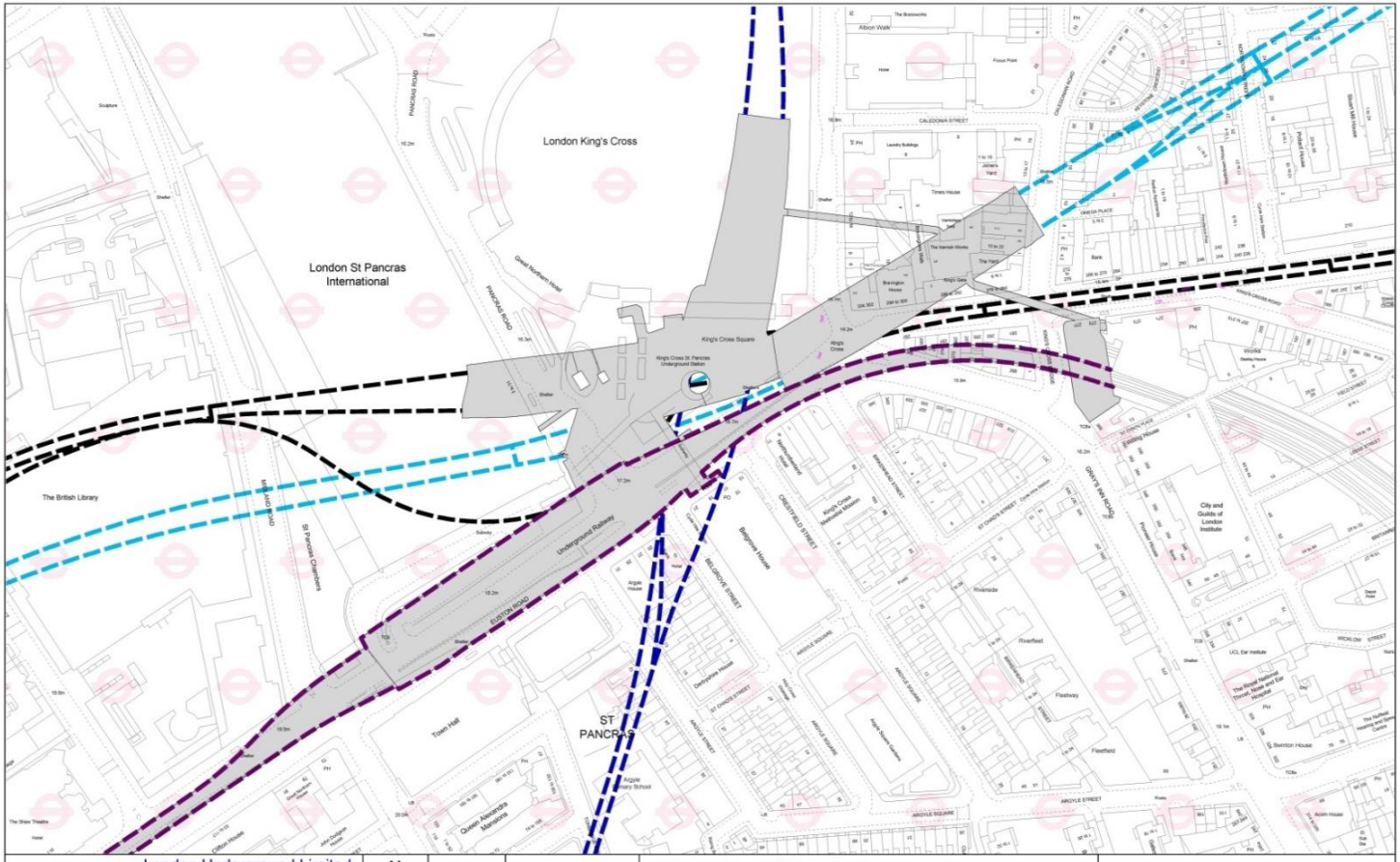


Paris, France

London, UK

Source: Google Maps, 2017.

Why is it important to understand how the past explains the future?
...these interfaces last for years; decades; and even centuries...



Source: London Underground

Why is it important to understand how the past explains the future?

...within changing urban environments

Junction of Gray's Inn Road and Kings Cross Bridge, London

Summertown Road and environs, Glasgow

Historic diagram source: The Illustrated London News , 1861. **Other Sources:** Bing Maps, 2017; Google Maps, 2016.

Why is it important to understand how the past explains the future?
These interfaces can be obvious...

Metropolitan and Thameslink lines north of Farringdon Stn.

Elephant & Castle LU Bakerloo line stn.

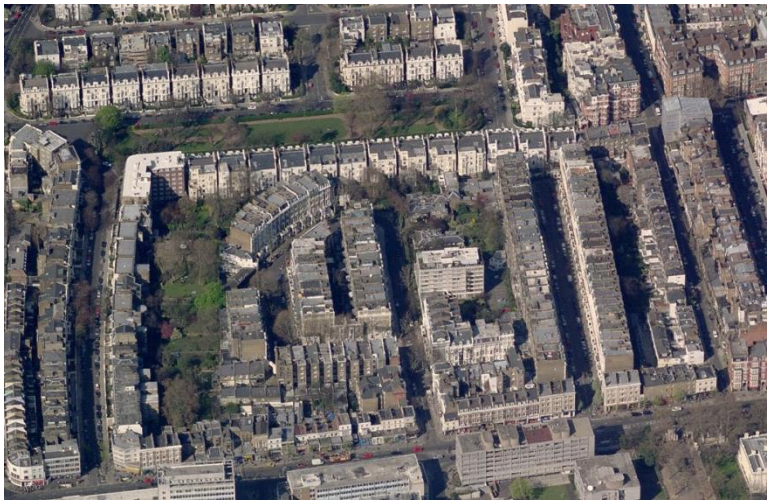
Canary Wharf LU Jubilee line stn.

Piccadilly Circus LU Piccadilly and Bakerloo lines stn.

Why is it important to understand how the past explains the future?

...and not so obvious...

River passing through tunnel crown of a sub-surface tunnel.



Linden Gardens, Notting Hill
Source: Bing Maps, 2017

Cheapside/St Paul's, London
Source: Bing Maps, 2017

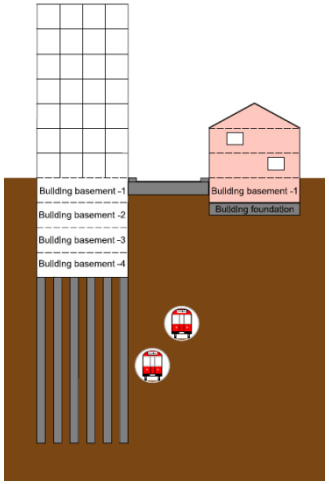
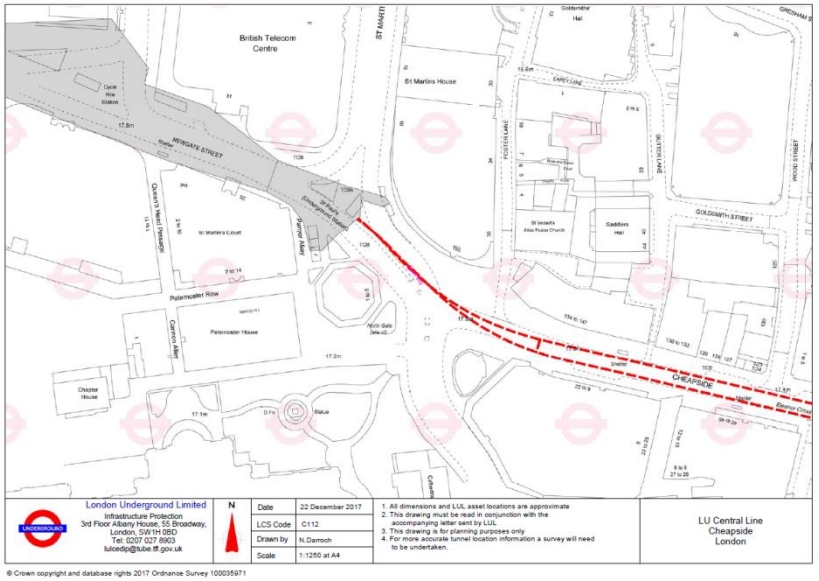


Diagram showing the generic relationship of tube tunnels with building foundations

Why is it important to understand how the past explains the future?

...either way these interfaces affect and are affected by their environment

Circle line, Porchester Terrace, Bayswater

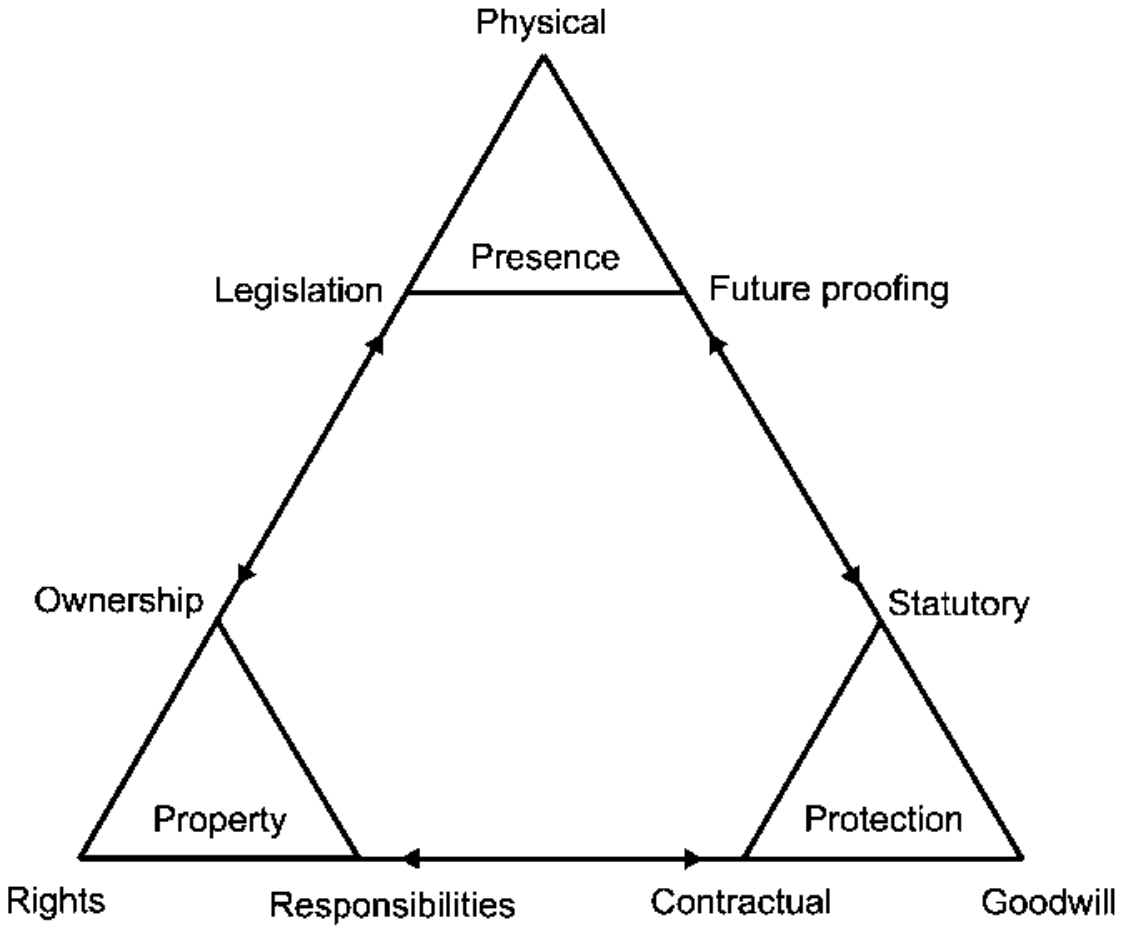


Plan showing the Central line under Cheapside
Source: London Underground

Hillingdon station, Metropolitan line

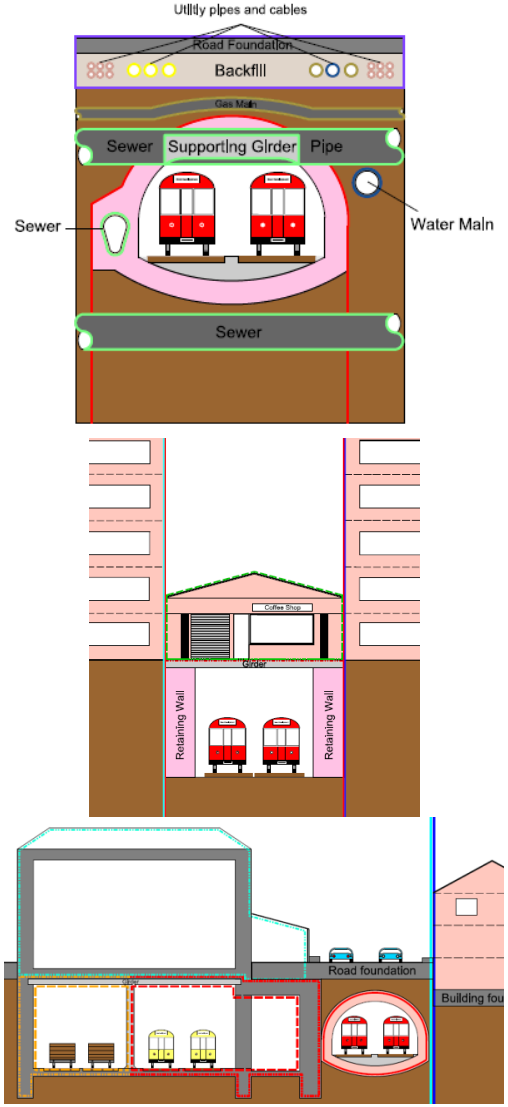
Building over District & Circle lines, St James's Park

The conceptual framework (Darroch, Beecroft, and Nelson 2016)

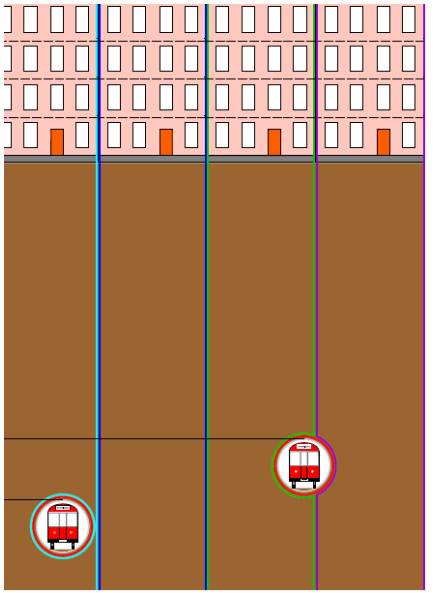


A conceptual framework showing the interfaces of UUMI and its environment.
Source: Darroch, Beecroft, & Nelson, 2016.

Over 40 different types of *physical* interface within TfL Fare Zone 1, alone



Physical Interface	**Location**	***Physical Interface***	**Location**
Sub-surface railway		***Tube Railway & stations***	
Tunnel under highway (*highway pre-existing*)	Craven Road, Bayswater	Tunnel under highway (*highway pre-existing*)	Charring Cross Road
Tunnel under highway (*contemporary*)	Charterhouse Street, Smithfield	Tunnels staggered under highway (different depths) (*pre-existing; post*)	Cheapside, City of London
Utilities interfaces with metro infrastructure (*pre-existing; contemporary; post*)	Aldgate East	Tunnels under building affecting building design (*post*)	British Library
Tunnel under building (*contemporary*)	Pembridge Square/Moscow Road, Bayswater	Station building with development over; and redevelopment of site (*post*)	Brompton Road Disused station
Railway within basement of building (*contemporary*)	Smithfield Meat Market, Farringdon	Escalator shaft from remote station building under building to platforms (pre-existing; *post*)	Angel, Islington
Railway within basement of building (*post*)	Westminster Station	Utilities subway within station infrastructure (*contemporary*)	Bank Station
Railway in cutting (*buildings adjacent: pre-railway; post*)	Campden Street, Kensington		
Railway in cutting: bridge over (*contemporary*)	Campden Street, Kensington	**Key to terms:**	
Railway in cutting with bridge over (*contemporary; separate span owners*)	Leeke Street, Islington	*Pre-existing* - The urban asset was present before the railway.	
Railway in cutting with bridge over (*post*)	St Botolph Street, Aldgate	*Contemporary* – the urban asset was provided with or about the same time as the railway.	
Railway in cutting with building over (*post*)	Palmer Street, Westminster	*Post* – the urban asset was provided/changed post railway construction.	
LU railway in cutting adjacent to Network Rail in tunnel (*contemporary*)	Swinton Street, Islington		
Road, over railway, over railway (*contemporary*)	Ray Street, Farringdon		
Bus station over railway (*post*)	Aldgate Bus Station		



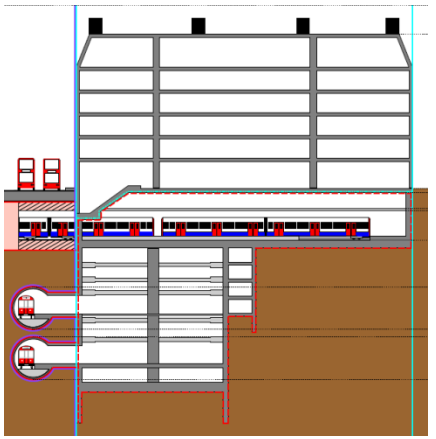
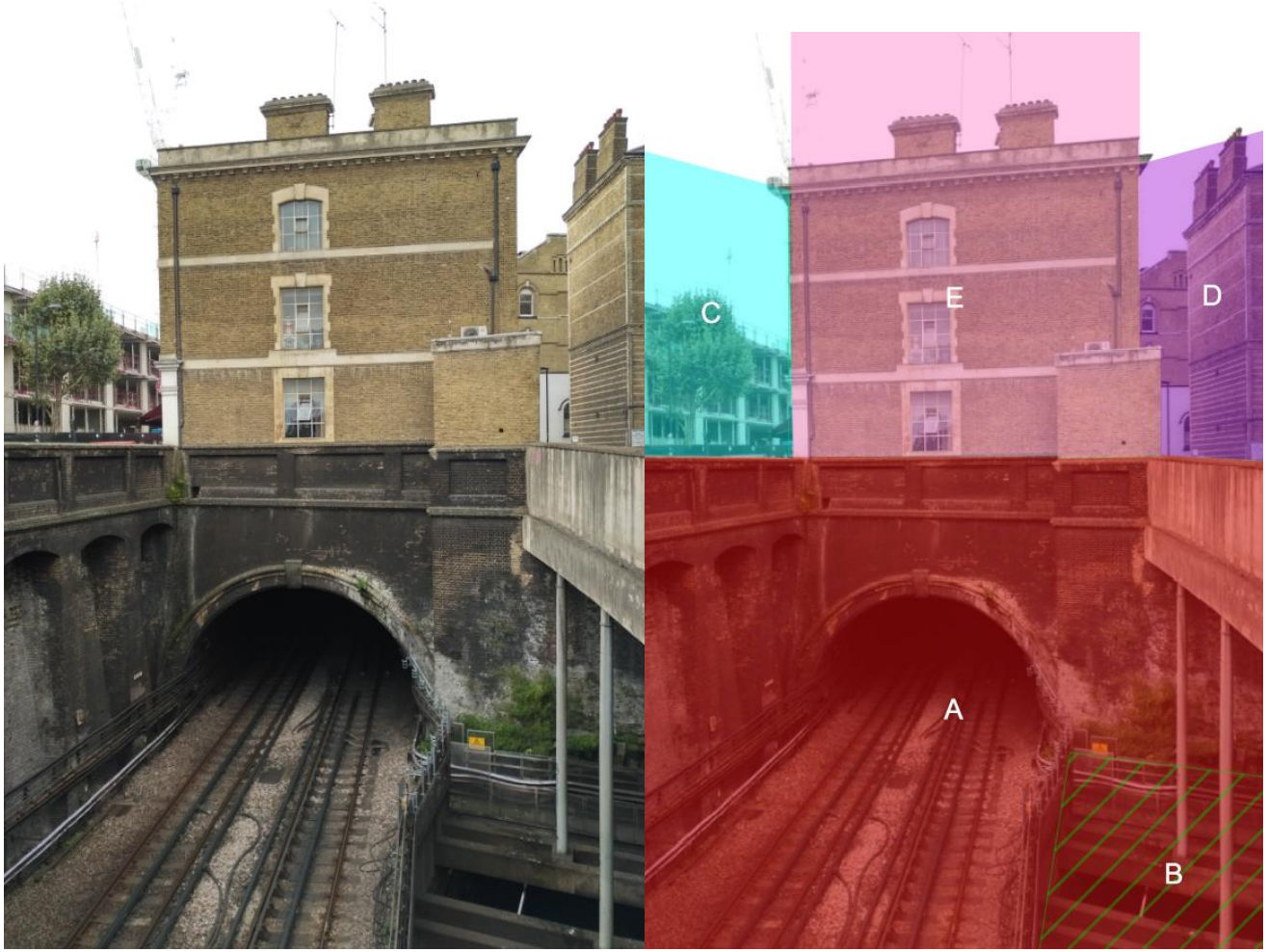


Table showing 20 scenarios of the physical interface between Urban Metro Infrastructure and its environment, in London
Source: Darroch, 2019.

Each with its own *property* and *protection* interfaces



Photograph showing 54 Farringdon Road and some of its physical interfaces; and with some of the property features overlaid.

Red (A) =
London Underground land and airspace

Hatched Green (B) =
Network Rail land and airspace (below)

Light blue (C) =
TfL Streets highway

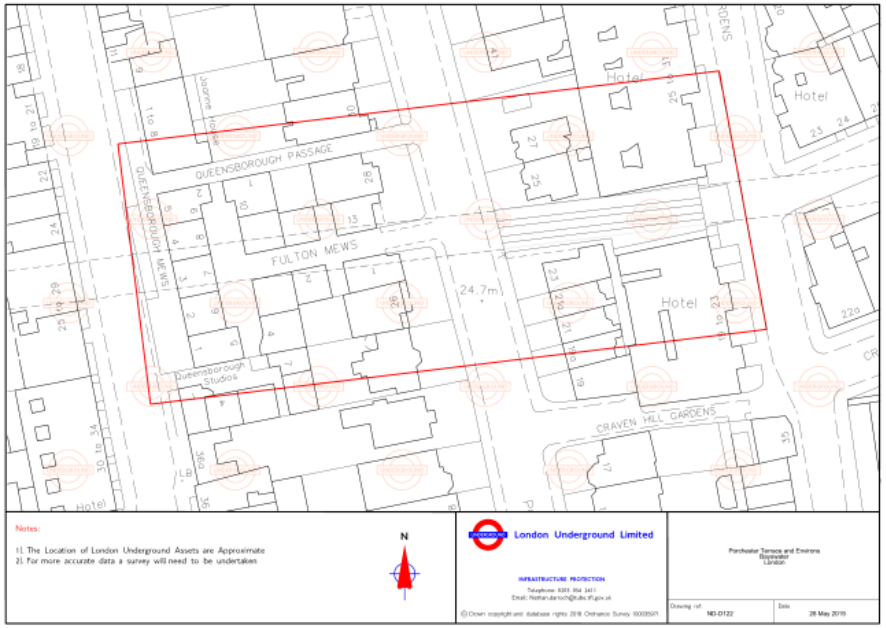
Purple (D) =
Local authority highway

Pink (E) =
Building owner

Analysing the interfaces of Urban Underground Metro Infrastructure

Establishing context – what is the scenario?

TfL Aerial Image showing Porchester Terrace and environs.
Source: TfL.



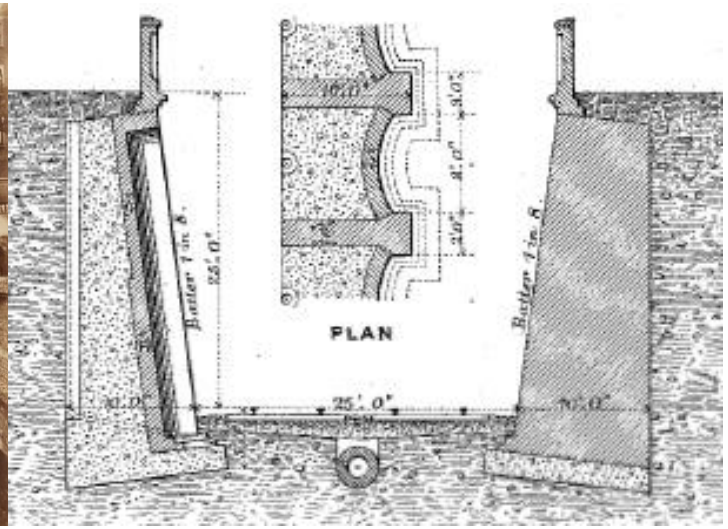
OS Mapping showing Porchester Terrace and environs.
Source: TfL.

Bing Maps 'Streetside' image showing the present day view of 19-23 (right) and 25 (left) Porchester Terrace.
Source: Bing Maps, 2017.

Analysing the interfaces of Urban Underground Metro Infrastructure
Establishing context – looking at the history of the scenario

Photograph showing the construction of the UUMI at Porchester Terrace looking east.
Source: The Sun, undated.

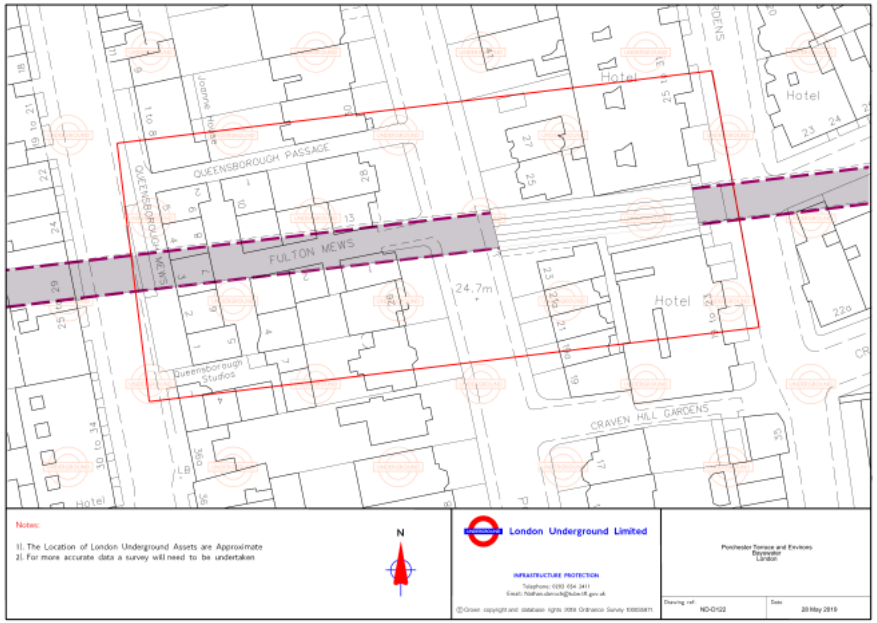
Photograph showing the effects of UUMI construction, Porchester Terrace, London.
Source: The Sun, undated.



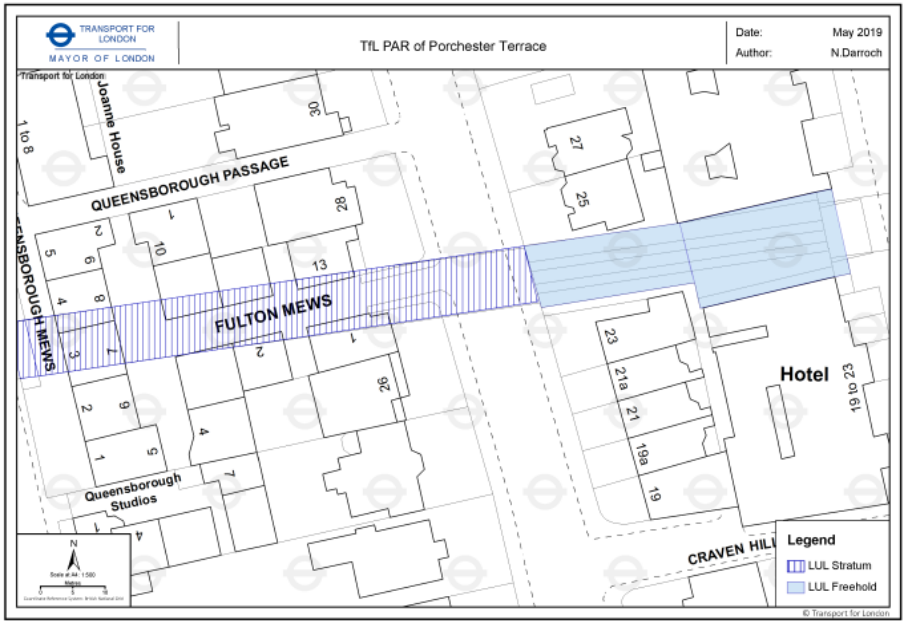
Extracted drawing, showing a typical cutting and retaining walls on the extension of the Metropolitan line to South Kensington. **Source:** Baker, 1885.

Analysing the interfaces of Urban Underground Metro Infrastructure
Depths of analysis – to develop comprehension

Holistic	=	Environment of the UUMI
Macro	=	Overview of the immediate environment to the UUMI
Micro	=	Detail of asset interfaces



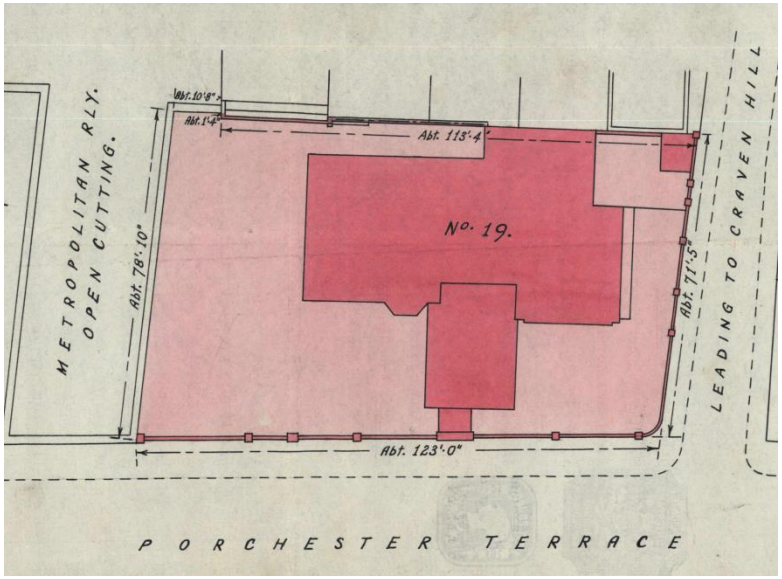
1:1250@A3 plan showing the alignment of the LU Circle line overlaid on OS mapping.
Source: London Underground.



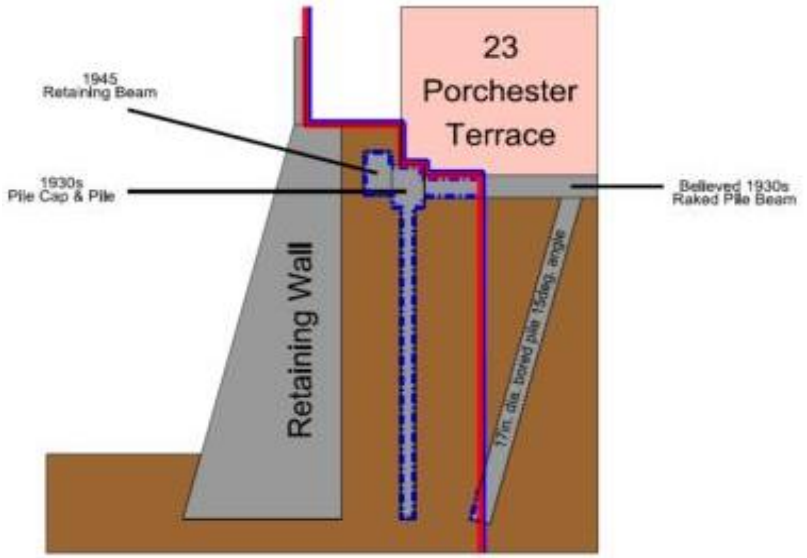
1:1250@A4 plan showing the LU Property interests overlaid on OS mapping.
Source: TfL, 2018.

Analysing the interfaces of Urban Underground Metro Infrastructure

Depths of analysis – of the past, current, and future interfaces



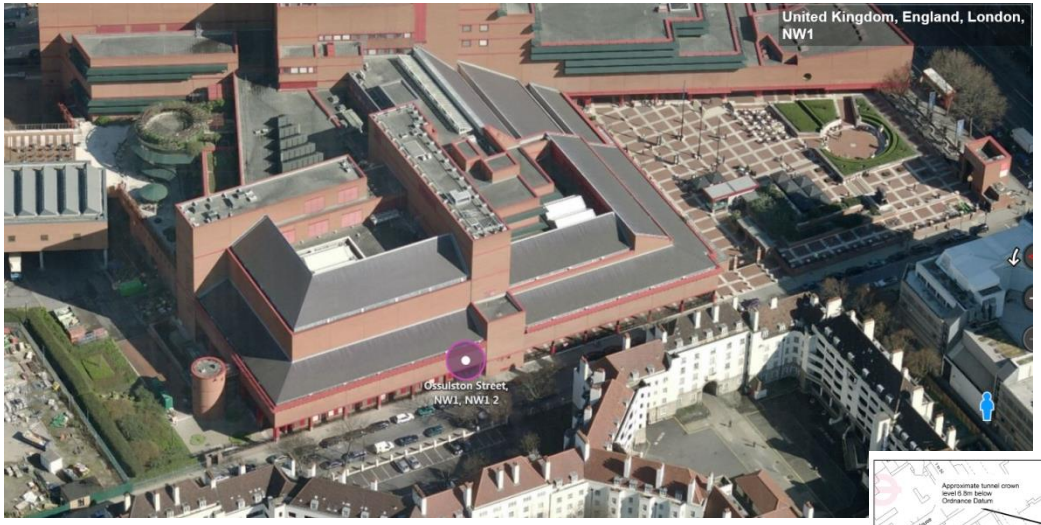
Extracted drawing from the conveyance of 1930 showing the land sold.
Source: TfL.



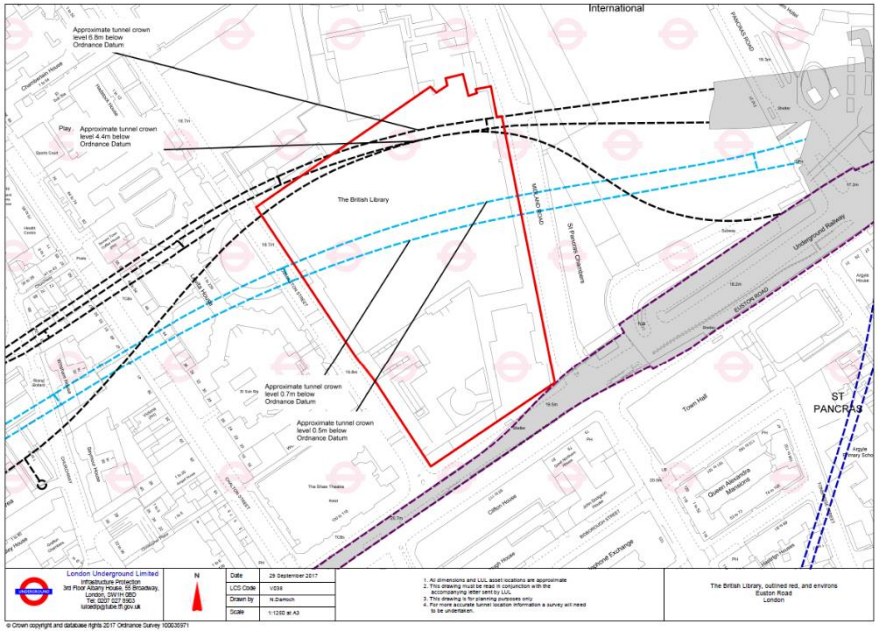
Diagrammatic representation of the interfaces of the UUMI and its related interfacing urban infrastructure.

Bing Maps 'Streetside' image showing the present day view of 19-23 (right) and 25 (left) Porchester Terrace.
Source: Bing Maps, 2017.

The British Library –
A building located over tube tunnels and adjacent to a sub-surface tunnel

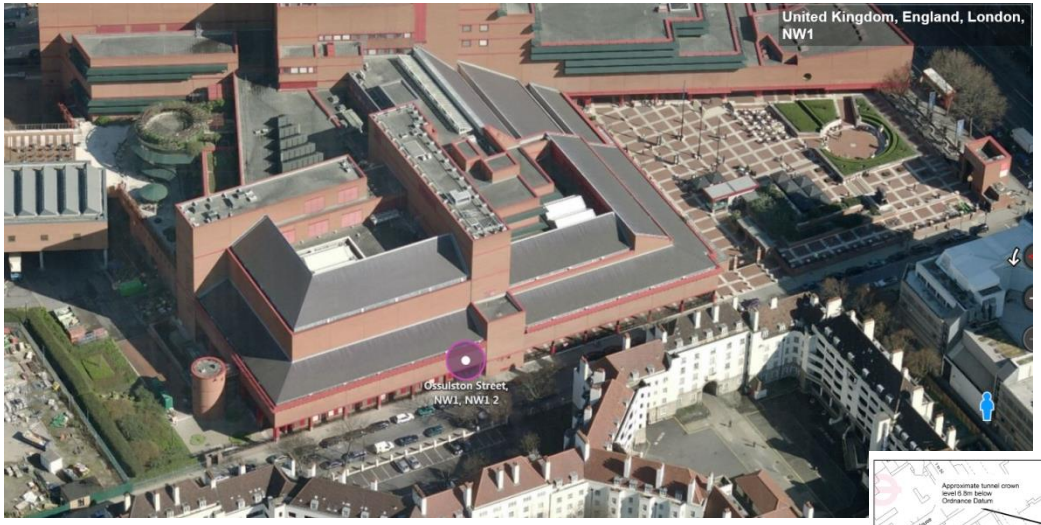


Satellite image showing the British Library looking east.
Source: Bing Maps, 2017.



Plan showing the alignment of the Northern and Victoria lines in relation to the British Library.
Map source: London Underground.

The British Library –
Which came first and what are the age differences?



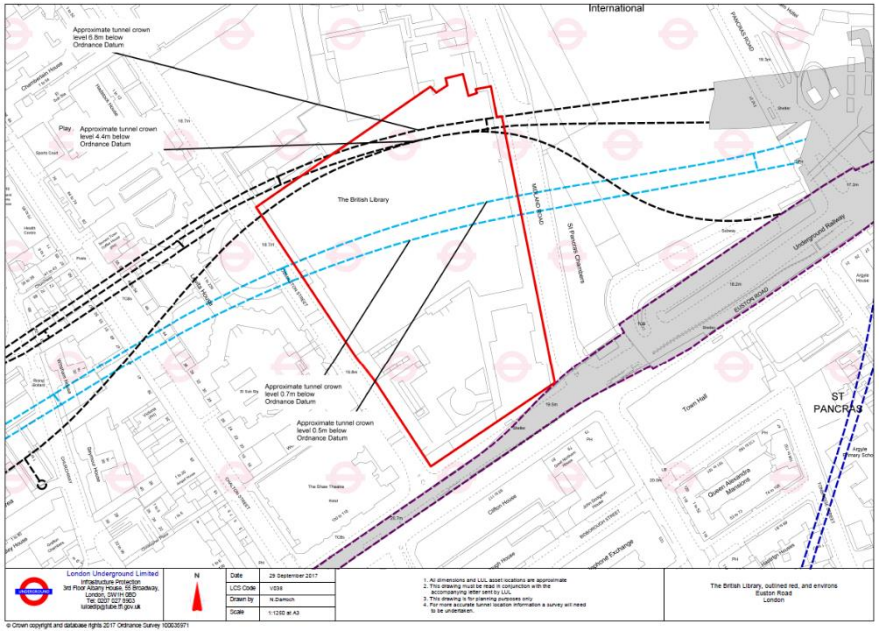
The current British Library was built in the 1990s;

The Metropolitan line opened in 1863;

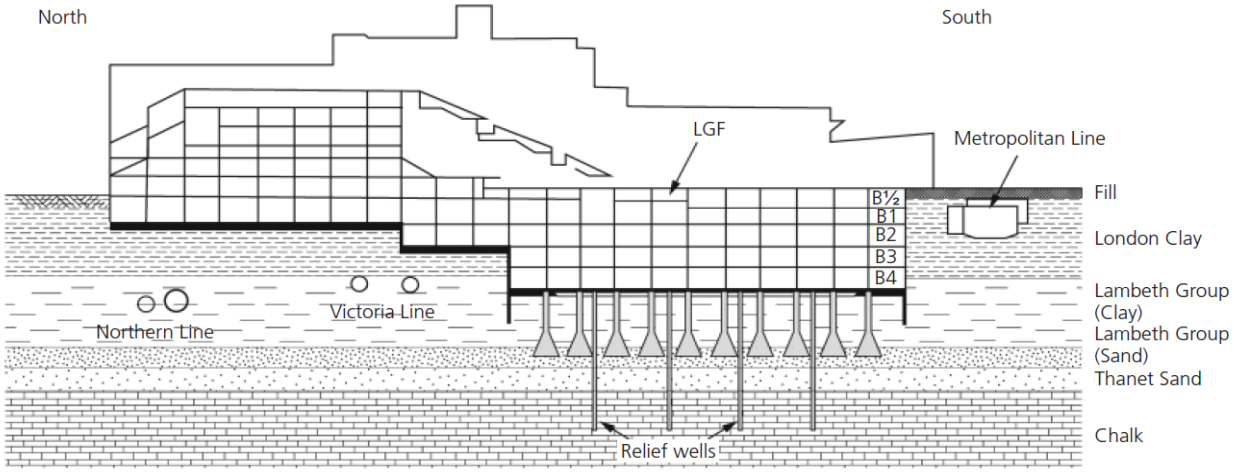
The Northern line opened in 1907;

Kings Cross Metropolitan line station opened in 1941;

The Victoria line opened in 1968.



The British Library –
The presence of the tunnels has a long-lasting effect on their environment



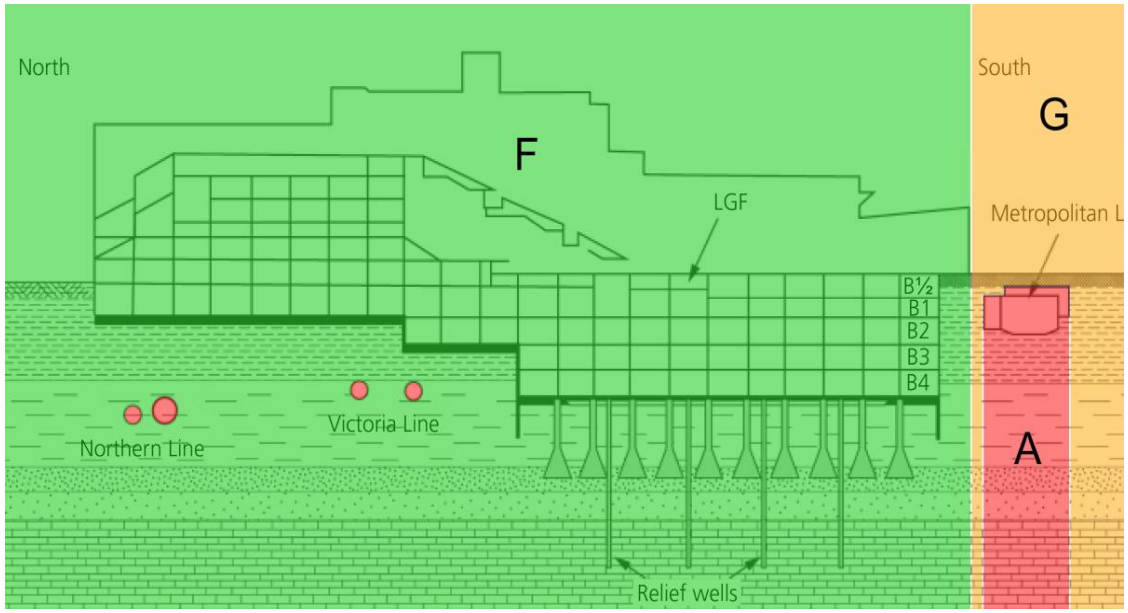
Section through the British Library showing foundation and building design.

Drawing source:
Simpson, B., and Vardanega, P., 2014.

Green (F) =
Freehold of the British Library;

Red (A) =
Freehold of London Underground;

Yellow (G) =
Undetermined.



Section through the British Library showing foundation and building design; and with some property features overlaid.
Drawing source:
Simpson, B., and Vardanega, P., 2014.
Property data source:
TfL Property Asset register.

Outputs from the analysis (Darroch, 2019)

Evidence-based findings

In the last 5 years the research identified & clarified, across the 11 LU lines, ***659 asset interfaces*** using ***53 different sources*** of data.

Of these interfaces, **414** were already ***identified***, ***but not clarified***; **245** were ***undocumented***.

Example figures include, but are not limited to:

- o District (Upminster to Aldgate East and some various) clarified ***179 identified*** interfaces;
- o District (Upminster to Aldgate East and some various) clarified ***70 undocumented*** interfaces;
- o Circle line (Farringdon to Edgware Road/Various) clarified ***130 identified*** interfaces;
- o Circle line (Farringdon to Edgware Road/Various) clarified ***69 undocumented*** interfaces;
- o Piccadilly (Heathrow: T5, T4 via T1, 2, 3) clarified ***35 identified*** interfaces;
- o Piccadilly (Heathrow: T5, T4 via T1, 2, 3) clarified ***17 undocumented*** interfaces;

• Additionally, ***33 site specific reports*** were produced clarifying occurences of the interfaces.

However, that data ***is not*** available to the business.

Outputs from the analysis (Darroch, 2019)

Documenting findings

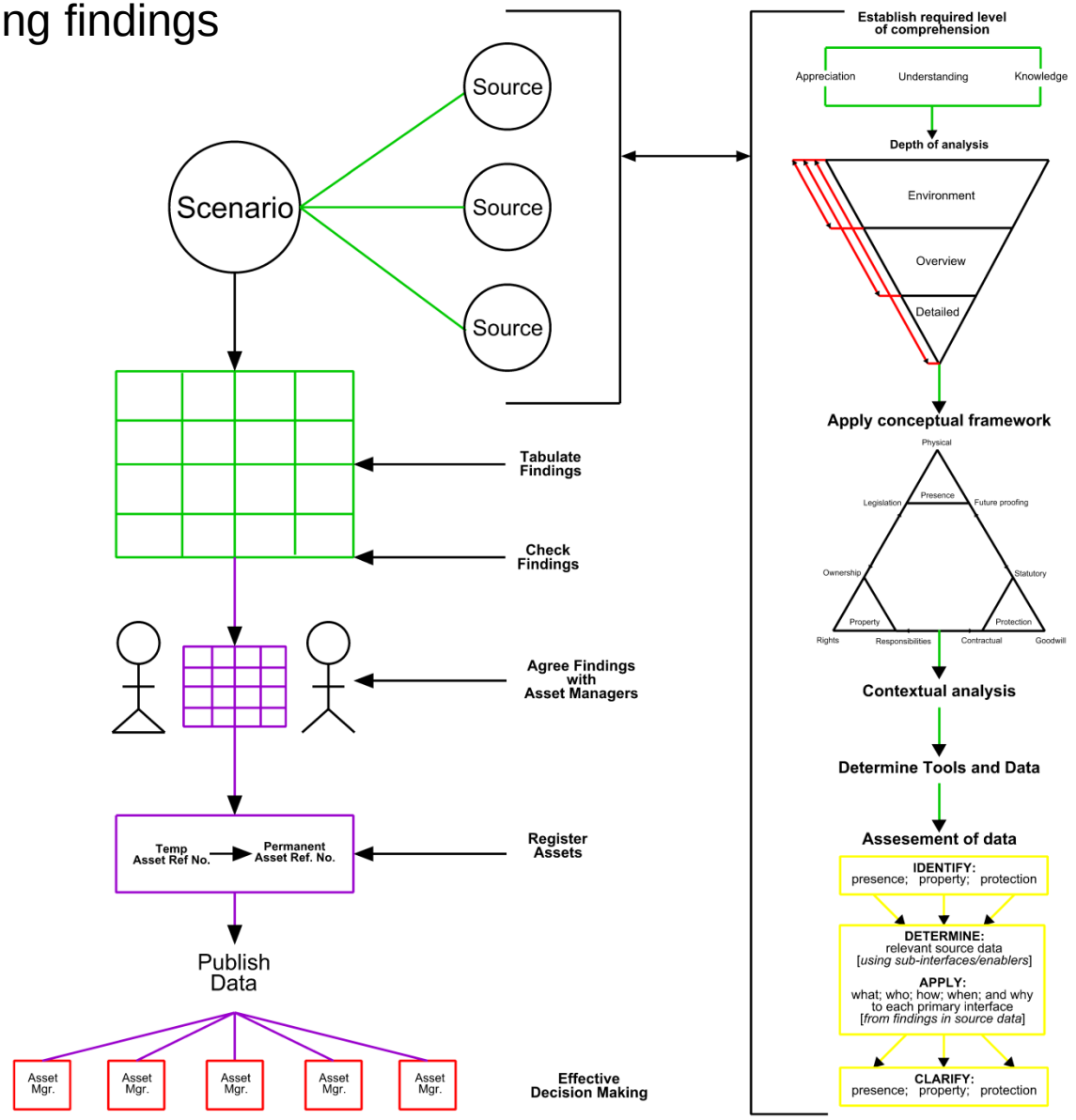


Diagram showing the interface analysis and documentation processes.
Source: Darroch, 2019.

Outputs from the analysis (Darroch, 2019)
Effective informed decision making

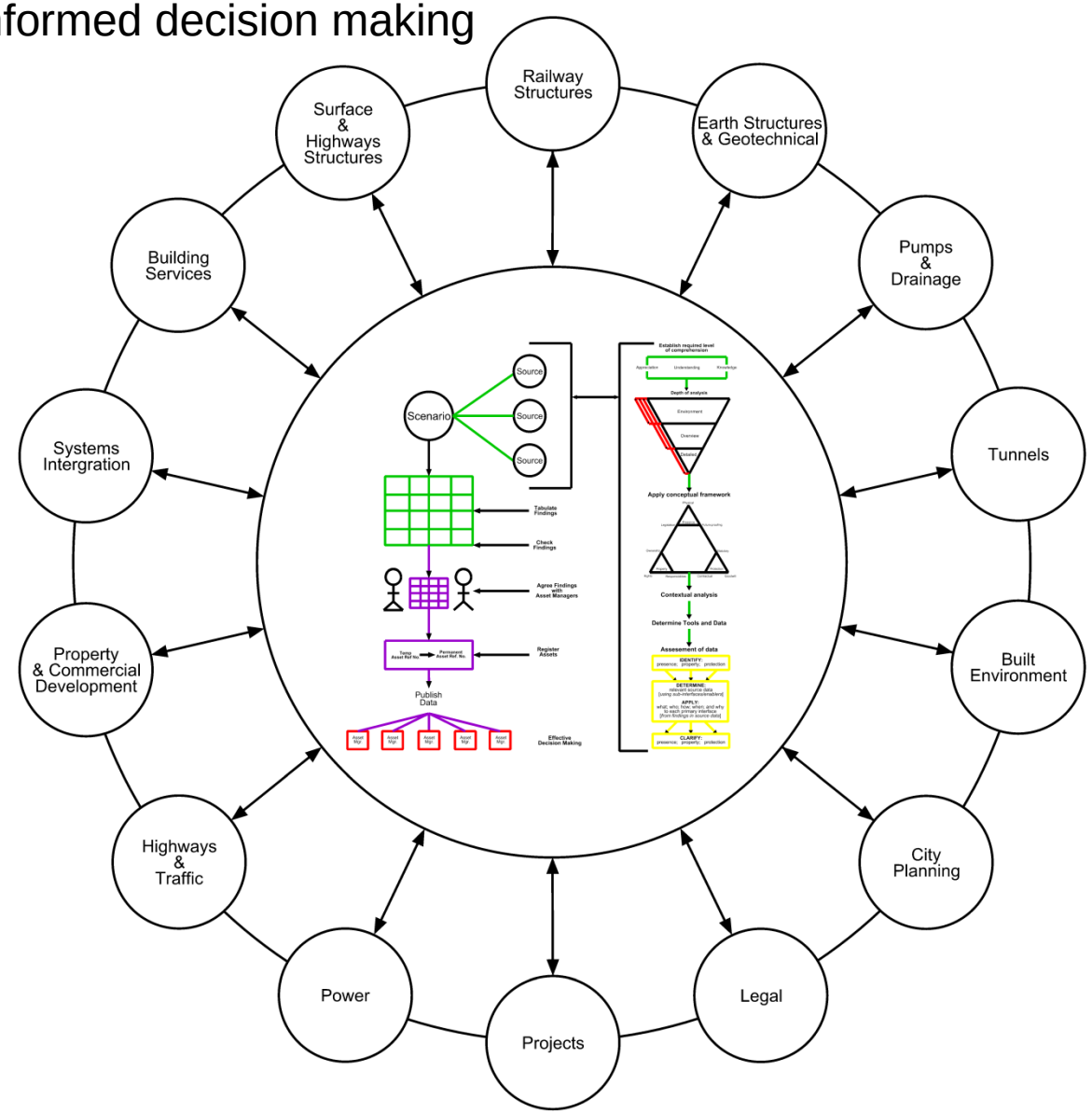
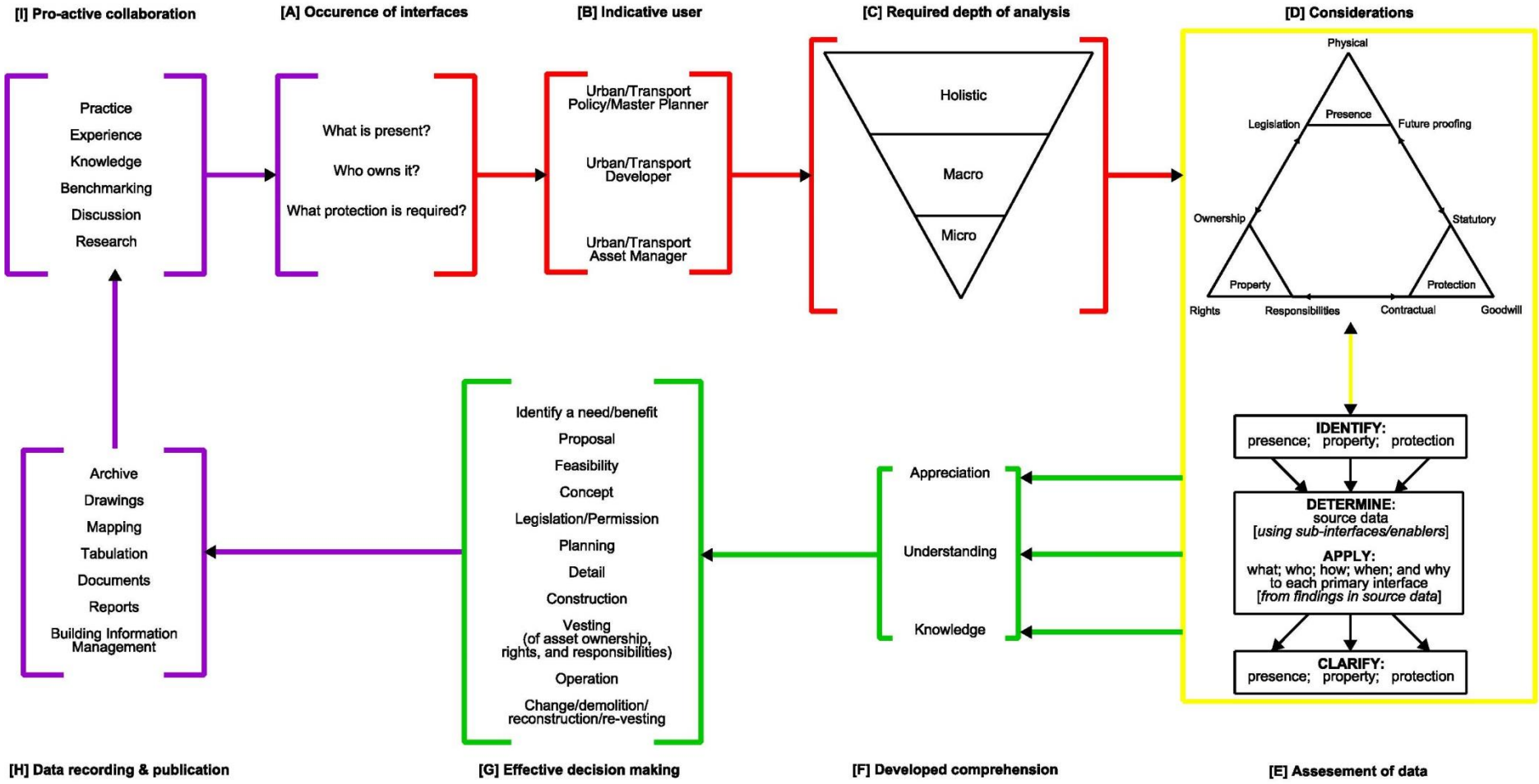


Diagram showing the indicative beneficiaries of the interface analysis and documentation processes, based on departments within TfL.
Source: Darroch, 2019.

Potential outputs from the analysis (Darroch, Beecroft & Nelson, 2018)
Whole life comprehension of interfaces

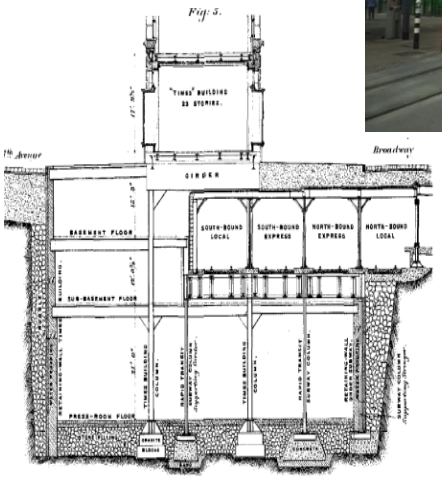


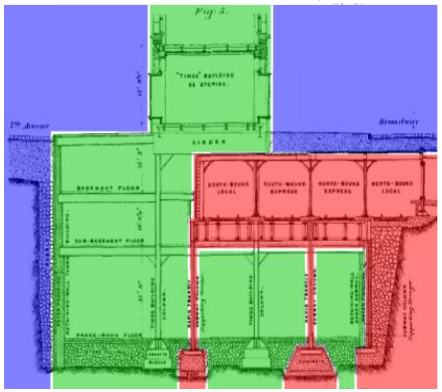
Operationalizing the conceptual framework workflow.
Source: Darroch, Beecroft, & Nelson, 2018.

Potential outputs from the research (Darroch, 2019)

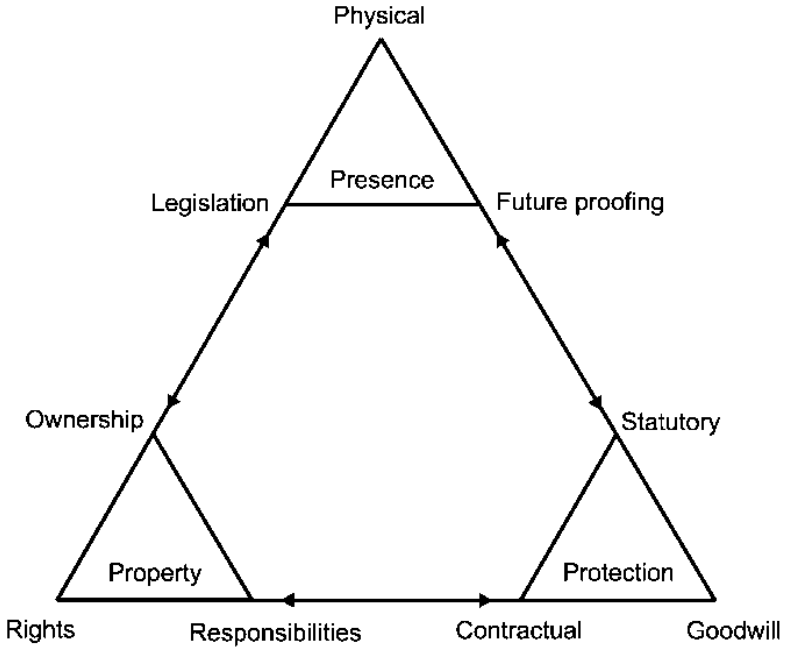
Transferability

Urban surface tramway passing under apartment building in Den Haag, Netherlands.

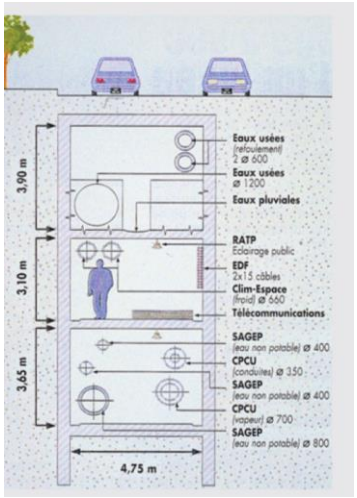




Section of the first, ground, and basement levels of One Times Square showing the physical interfaces forming the Subway UUMI and the building, with presumed property interfaces overlaid. **Source:** Based on information within Purdy, 1909.



A conceptual framework showing the interfaces of UUMI and its environment.
Source: Darroch, Beecroft, & Nelson, 2016.



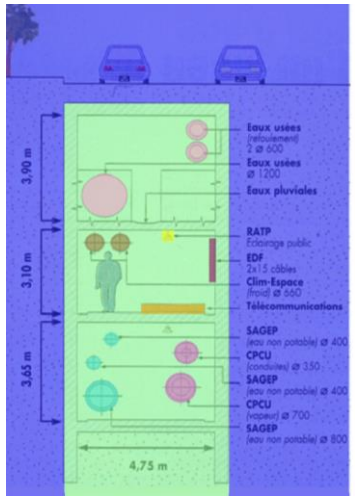


Diagram showing the design of a multi-level utilities subway (utilidor), in Paris, France, with example property interfaces colour shaded representing the utilities providers identified within the original drawing.
Source: National Research Council, 2013.

How does understanding urban metro infrastructure explain the past, the present, and the future

Transport infrastructure does not exist in isolation.

Nor does its environment.

Comprehension of the *existing* interfaces of transport infrastructure and its environment today, enables effective, sustainable:

proposals for; and the

planning;

construction;

and management;

of transport infrastructure and its environment tomorrow, and for the future.

This is essential given the continuing urbanisation of populations and densification of cities, globally.

The findings and outputs of this research can and will enable transport infrastructure owners, and their interfacing stakeholders to understand these interfaces, internationally.

How does understanding urban metro infrastructure explain the past, the present, and the future

By employing these processes, transport infrastructure owners/managers and their interfacing stakeholders can:

- develop *more effective* strategies for the planning and undertaking of asset management for existing and future infrastructure and their interfaces with their environment;
- *plan, design, and construct* future infrastructure whilst ensuring sustainable environmental development and change for the whole lifecycle of that infrastructure, its interfaces, and its environment;
- benchmark practices and learn from national and international practices of other transport infrastructure owners/maintainers;
- encourage the development of knowledge and understanding of existing and future multi-disciplinary practitioners, through connections to academia;
- effect the development of and changes to business, local, national, and international standards to create an effective mechanism of sustainable development, change, and management for transport infrastructure and its environment.

Next steps and research

Academic research and business practices are not mutually exclusive.

They must learn from one another whilst advising each other how to improve.

This research and its outputs will therefore continue to be promoted and developed, nationally and internationally, through:

- continuing research;
- academic and innovation research funding;
- workshops;
- conference presentations;
- lectures at universities;
- participation in policy development;

but these must be achieved through collaboration with pertinent transport infrastructure owners/managers, their interfacing stakeholders, academic, and professional institutions locally, nationally, and internationally.

Thank you for listening

Any questions?

My thanks to all colleagues within TfL for your interest and support;

Especial thanks are extended to:

Francine Fuller

and

Michael Bobrowicz

for their support and collaboration in this research and the development of **AIR**.

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Website: www.nathandarroch.co.uk

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