Discussion Paper

under the viaduct

Neglected Spaces *No Longer*

ARUP

Under the viaduct: Neglected Spaces No Longer is a publication initiated and prepared by Arup in partnership with the New South Wales Roads and Maritime Services (RMS). Preparation of the report has involved close collaboration between Arup teams in Sydney, Melbourne, London, Johannesburg and New York.

The views, concepts, designs, and recommendations presented in the publication do not necessarily represent those of RMS.

Contacts

Matt Lally
Associate Director, Integrated City Planning
London
matt.lally@arup.com

Gareth Collins
Director, Centre for Urban Design
Roads and Maritime Services, NSW
Sydney
gareth.collins@rms.nsw.gov.au

Safiah Moore
Senior Planner, Landscape + Urban
Sydney
safiah.moore@arup.com

contents

foreword

Gareth Collins
Director, Centre for Urban Design, RMS
Fellow, Australian Institute of
Landscape Architects

Under the Viaduct: Neglected space no longer came about through a meeting between Matt Lally and myself in Sydney 2015. We were discussing the potentials for collaboration and exploring the differing perspectives of our organisations: the New South Wales (NSW) Roads and Maritime Services (RMS) the custodian of a vast road and bridge asset and Arup a global firm of planners, designers and engineers.

This idea began with a discussion about the revitalisation of the unused 80 year-old Sydney Harbour Bridge viaduct undercroft space (then underway) and moved on to how this type of thinking might apply to the many thousands of bridges in NSW, Australia and globally.

Since then, the Sydney Harbour Bridge viaduct space has been turned into a state-of-the-art government office for Roads and Maritime Services. With high ceilings, staircases, generous natural light, art deco architecture and a rich engineering and design heritage, the renovation has provided a beautiful place to work and made use of a valuable part of the city. It has enhanced the security of the bridge, saved the public purse significantly in otherwise ongoing rent and helped the area economically.

Although an unusual and rare opportunity in a globally recognised piece of engineering, clearly this exercise has demonstrated that turning under-bridge space into something more than idle, vandalism prone land has great value.

Of course this isn't the first use of such space and the Westway project in London is a fantastic example. However, it is probably one of the first uses of viaduct space as an office of a State Government organisation, and of course the Sydney Harbour Bridge has a certain global prominence and exemplar role.

In NSW we are currently in the midst of our largest transport infrastructure building program. The Sydney Harbour Bridge helped connect the two sides of the city and provided essential work in the Great Depression, but the work underway now is across all of Sydney and the state. It involves rail, roads, bridges and tunnels. Combined with this the population of Sydney is expanding rapidly at approximately a million people every decade. We need to get more out of this infrastructure program and use it to create places of value to communities, government and industry as well as for transport.

This document is a statement of principle for any program of work or asset anywhere in the world. We need to get more value from our infrastructure and bridges in particular, because as well as carrying loads they are incredibly durable roofs and full of possibilities.

under the viaduct

Neglected Spaces *No Longer*

executive summary

Under the Viaduct: Neglected space no longer *summarises work undertaken across five Arup offices, namely Sydney, Melbourne, London, Johannesburg and New York. It focuses on the spaces underneath elevated road and rail viaducts, often ignored or marginalised in the planning and design process, and identifies how, with creative imagination and design skill, such spaces can be put to a wide variety of productive uses.*

This research aims to explore the potential for creative *reuse* of existing viaduct infrastructure – the 'rooms' created by bridging infrastructure – as well as the potential to design more purposeful uses of these spaces into *new* infrastructure.

Objectives:

1. Identifying international case studies to inform and inspire
2. Categorising elevated transport infrastructure into distinct types for investigation
3. Testing and demonstrating the creative potential for undercroft activation through design exercises
4. Summarising the technical, institutional and policy challenges
5. Capturing first-hand insights through consultation with stakeholders
6. Determining the benefits that viaduct activation can yield
7. Identify potential site-specific design opportunities
8. Developing delivery recommendations for practical application

The research origins were influenced by observations of poorly conceived viaducts around the world – severing communities, creating dead-end streets and lifeless voids – what Jane Jacobs referred to as "border vacuums." However, it was also inspired by the panoply of international examples of viaduct undercroft spaces that have been successfully activated to create places of immense social, environmental and economic value – whether bars, cafes or nightclubs buzzing with life and acting as a catalyst for wider urban regeneration, or workspaces offering local employment opportunities, or indeed public space, art, play or sports facilities adding much needed community health, wellbeing or cultural facilities.

The backcloth of continuing densification of the world's cities, means that such investigations are becoming ever more relevant. The need to squeeze much greater levels of land use efficiency out of existing urban areas is becoming more acutely felt – with attention turning to spaces that have hitherto been considered of a marginal nature. Meanwhile, public sector bodies responsible for the delivery and ongoing management of transport infrastructure are under ever greater levels of public scrutiny in relation to the value for money of major infrastructure investment and the public benefit that this is intended to leverage. This is leading to alternative models for funding delivery to be defined that include identifying revenue streams that help cross-subsidise the large capital outlays. Viaduct activation can make a positive contribution to these wider city-shaping objectives in not only creating places of community benefit, but also helping to boost overall project viability and investment return.

To explore the potential for better utilisation of spaces under both existing viaducts (through retrofitting) and proposed new-build projects (through designing-in activation from the outset), the project applied an enquiry-by-design approach. This involved the selection of seven international case studies to undertake a 'deep dive' into the challenges faced and to draw out opportunities through design investigation. Although each of the design exercises was hypothetical in nature (for sites located in Sydney, Melbourne, London and Addis Ababa), each was considered to represent a realistic proposition and was informed by consultation with locally-based stakeholder organisations with a responsibility for the viaducts and / or spaces underneath. Different departments of the New South Wales Government were particularly helpful in supporting the project's evolution.

Drawing upon these case study investigations and inspired international examples of successful viaduct activation, the report summarises a series of findings to help inform future practice. Most fundamental of these relates to the way that transport infrastructure is conceptualised, and how this is reflected in the project brief, project team composition and approach to planning, business case and design execution. The starting point for success is to explore the potential for viaduct structures and the spaces they shelter as seams rather than barriers, as the potential means to unite rather than separate. This requires that viaducts are not solely approached as 'engineering infrastructure' or 'traffic conduits' but integrated pieces of the city fabric woven into their context and projecting life and animation. Rather than being conceived solely as a linear route-way, a more expansive approach to viaduct project framing is adopted in terms of:

- spatial scale (addressing neighourhood interfaces, corridor networks and city-wide impact)
- project scope and definition, and
- institutional delivery mechanisms (not just a transport team, but a fully multi-disciplinary team of engineers, planners, urban designers, landscape architects and economists).

A series of technical guidelines are defined to encourage the creative reuse of existing viaduct infrastructure to be given focus – the 'rooms' created by bridging infrastructure – as well as the potential to design more purposeful uses of these spaces into new infrastructure. These cover:

- urban planning
- business case preparation
- engineering design
- other technical design challenges, particularly 'soundscaping' acoustic requirements

Drawing on insights from case studies and design exercises, process guidelines are also defined that give encouragement for issues and opportunities of viaduct activation to be addressed at each stage in the project lifecycle (initiation – planning – business case – design – build – governance + operation) in an iterative way that, for example, addresses the management and maintenance of these spaces at the outset.

The starting point for success is to explore the potential for viaduct structures and the spaces they shelter as *seams* rather than *barriers*, as the potential means to *unite* rather than separate.

Key messages related to process are:

Establish the vision for infrastructure in relation to delivering community benefits.
Design in features that promote flexibility in the use of viaduct spaces
Design with the community, tapping into local knowledge and responding to local need
Demonstrate public value early through the business case process and potentially through early demonstrator projects (either of a temporary or permanent nature)
Identify the ecosystem to support activation and occupation of space, the people and processes required to make it a success
Develop a set of clear, measurable and ambitious goals that are evidence-based to inform implementation
Monitor the success of viaduct space utilisation against the performance metrics set

The report concludes with recommendations for further research relating to strengthening the evidence base, business case preparation, regulations that are defined to facilitate rather than constrain, structural design for adaptability, planning for flexibility and community involvement.

urban isation

An opportunity as much as it is a challenge

under the viaduct

Designing-in public value

Growth in cities is being experienced globally, with populations in some cities like Sydney projecting to double over the coming years. Compact city development that makes the most efficient use of land, accompanied by the infrastructure needed to support intensification, will increasingly be the norm as cities turn away from low density sprawling suburban models and strive towards liveability and sustainability outcomes. In some instances, new elevated transport infrastructure (whether light rail, metro or motorways) is being introduced to oversail the existing city fabric to minimise surface level impacts on existing properties and transport systems or span over waterways, whilst in new growth areas, these can be integrated into development plans from the outset.

Poorly conceived, such transport infrastructure can have a major severing effect on existing neighbourhoods. Elevated structures can pose significant barriers to pedestrian movement and the 'left over' or residual void spaces below the elevated structures are often under-used and neglected, creating a blighting impact and sometimes becoming a focus for anti-social behaviour. Designing for successful relationships between infrastructure and interfacing neighbourhoods will be key to overall successful integration into the city fabric – providing a valuable contribution to the city where such interfaces are well conceived. Yet all too frequently this approach to integrated city-making is not applied.

Historical precedents of Nineteenth Century railway viaducts of London, Paris or Berlin, for example, demonstrate how these structures can become sewn into the city fabric. Viaduct arches have proven to be versatile spaces for conversion to a wide range of uses. Take Paris's Viaduct des Arts, with its shops, creative studios and galleries, animating adjacent streets and beautiful Promenade Plantée above[1]; or the cultural, creative and community uses accommodated under London's Westway[2]; or indeed the inventive public spaces of the A8ernA Project in Koog aan de Zaan, Netherlands[3].

1. https://en.wikipedia.org/wiki/Viaduc_des_Arts
2. http://www.westway.org/
3. http://www.publicspace.org/en/works/d046-a8erna

1/ ©Westway Trust
2/ ©Westway Trust
3/ Viaduct des Arts, Paris ©Alamy
4/ Viaduct des Arts, Paris ©Alamy

1/

2/

3/

4/

The potential is huge, and yet often ignored during the design process. Elevated roads and railways are often narrowly conceived as structural engineering projects with little thought given to their ‘under spaces’ and adjacencies. In many instances one often sees such uses colonising the viaduct spaces years after completion, but often as an opportunistic after-thought rather than integrated into the project brief at the inception of the design process. How might we consider reversing this situation?

Research aims

To explore the potential for better utilisation of spaces under existing and proposed new road and rail viaducts, using an enquiry-by-design approach to define creative potential solutions and provide guidance of international relevance.

This research explores the potential for creative reuse of existing viaduct infrastructure – the ‘rooms’ created by bridging infrastructure – as well as the potential to design more purposeful uses of these spaces into *new* infrastructure.

The study has been prepared to realise eight objectives:

1 Identify international best practice case studies

To identify creative ways that different types of elevated transport infrastructure have been transformed

2 Categorise elevated transport infrastructure for analysis

To establish distinct typological groupings according to physical conditions and development potential

3 Test and demonstrate the creative potential

To generate demonstrator concept designs relating to different undercroft spaces, using a select number of hypothetical projects to and understand issues related to their realisation through ‘enquiry-by-design’ exercises in collaboration with stakeholders involved in their practical delivery

4 Summarise the technical, institutional and policy challenges

To draw upon case study insights and concept design investigations to identify globally applicable lessons for wider dissemination that relate to the potential for both retrofit and new build

5 Capture first-hand stakeholder insights

To gather first-hand feedback through meetings with key stakeholders involved in design and delivery of transport infrastructure related to technical issues and technical barriers to overcome

6 Determine the metrics for success

To identify in qualitative and quantitative terms the economic, community and environmental benefits of creative re-purposing of viaduct spaces, drawing on international best practice and findings from practical project investigations

7 Identify potential site-specific design opportunities

To sow the seeds for projects where study findings could be applied in practice

8 Develop delivery recommendations

To make recommendations of local and global relevance – including technical design guidelines, improved design and delivery processes to achieve positive outcomes, and actions for taking the initiative forward with key stakeholders

Methodology

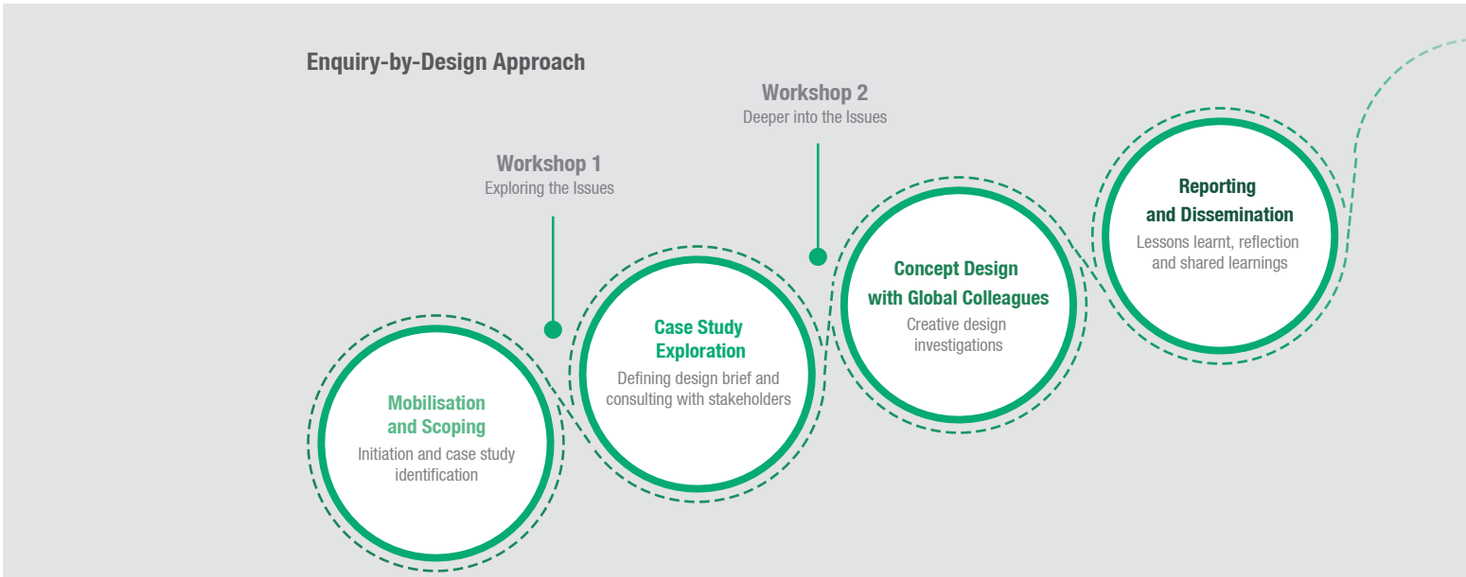
The research partnership

This report summarises research that has been undertaken by Arup across five offices, namely Sydney, Melbourne, London, Johannesburg and New York. As the work was instigated in Sydney, collaborative workshops were held with key New South Wales (NSW) Government departments[4] to provide insights into the design, procurement, management and maintenance of transport infrastructure. This ensured our research findings were informed by technical considerations and that the findings have practical application.

The research team combined a breadth of related Arup disciplines, including structures, bridges, lighting, landscape, urban planning and rail/transport planning to provide a fully integrated, multi-disciplinary picture. Research support has been provided by the Arup University team in Australasia.

Process

A summary of our research process is illustrated opposite. Following two creative workshop sessions that helped frame the overall research scope and identify case studies for applying hypothetical but nonetheless realistic design enquiries, concept designs were prepared, often in consultation with local stakeholders to inject further insight and realism. From these seven 'enquiry by design' exercises, we derived some general learnings, which were shared internally and with collaborating organisations.



4. These comprised NSW Roads and Maritime Services (RMS), Transport for New South Wales (TfNSW) and UrbanGrowth NSW.

typologies

Different interventions for different types of spaces

©unsplash

typologies

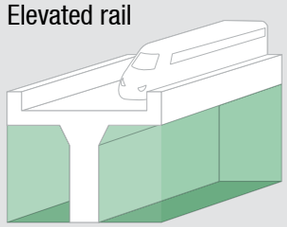
Two scales of typologies have been explored as a way of thinking about different undercroft spaces: typologies of form and typologies of occupation. Each typology presents particular opportunities and challenges for productive use.

Typologies of form

Four types of elevated infrastructure have been identified.

5/ Rouse Hill, Sydney: Image courtesy of Transport for New South Wales
6/ Westgate Freeway (M1), Melbourne: Image ©Google street view
7/ Westway Sports & Fitness Centre, London Image ©Westway Trust
8/ Middlemiss Street, Sydney (the undercroft to Sydney Harbrour Bridge ramp) Image © Matt Lally, Arup

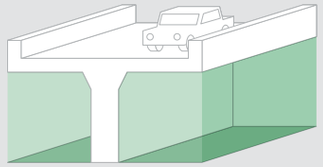
Elevated rail



5/

These vary in nature, from the brick railway viaducts and arches that were constructed in many cities throughout the Nineteenth Century, through the wrought iron elevated railways of the Nineteenth and early Twentieth Century, to modern concrete elevated rail structures. Within this category there is a wide range of different structural types relating to heavy rail, light rail and metros.

Elevated highways



6/

Elevated concrete highways are commonplace throughout the world. Due to the width of the roadway, the scale of the supporting columns and opacity of the material, undercroft spaces are often large-scale, dark and visually impermeable, often creating highly divisive barriers where they transect urban areas.

Highway junction

7/

Elevated highway junctions vary in geometric arrangement, with variations. Given their substantial land-take requirements they tend to be extremely difficult to integrate into the urban fabric, and their impact can have a major severing effect. The multi-layered, overlapping structures result in a fragmented complexity of void spaces – typically either left as characterless concrete hardscape or low-maintenance grassland, sometimes with feature planting for motor-borne visual amenity, but often with no or little pedestrian access.

Bridge ramp undercroft

8/

These void spaces occur where a bridge meets the land, such as on a river valley slope. Highway ramps can reach deep into the centre of cities, often creating dramatic structures elevated high above the city roof-scape or interspersed with other buildings. This can give rise to a wide variety of different undercroft spaces between structural columns, with the potential for a diversity of uses and building typologies placed underneath.

Typologies of occupation

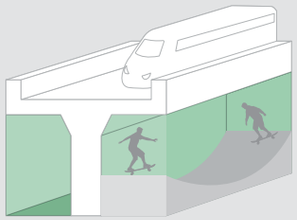
Four typologies of occupation opportunity have been identified. The potential for occupation will depend on the stakeholder group leading the intervention and the populations they serve.

A space may host a number of typologies of occupation over time. For example, during investigation stages, temporary public space may be installed for testing and feedback before further infill uses are established and developed.

“Turning under-bridge space into something more than idle, vandalism prone land has great value.”

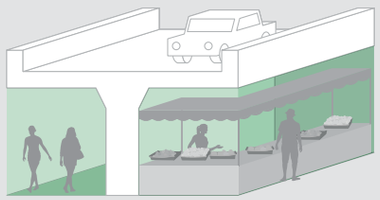
Gareth Collins
Director, Centre for Urban Design, RMS

Infill



Infill of viaduct void spaces can include retail, workspace or community use accommodation, for example. Activities can be either permanently accommodated or potentially take the form of temporary ‘pop up’ uses.

Landscape and public spaces



Spaces under the viaducts can be designed to accommodate urban life activities such as climbing walls or markets, planted with biodiversity and habitat creation in mind, or for simply visual amenity. They can be envisaged as public realm or more private spaces, depending on the circumstance.

Connectors

Connectors and pedestrian and /or bicycle links that extend laterally under the width of the viaduct to adjacent areas, or longitudinally to run along a corridor directly underneath the viaduct highway or railway structure, with associated lighting, wayfinding and landscaping measures.

Adaption

Adapted spaces can take a wide variety of forms, from measures that are applied to the viaduct structure (which may include for example coloured painting, lighting or artistic features), or elements that are grafted on to the principal structure (such as a raised pedestrian walkway that is bolted to the structure underside).

Inspiration

Throughout the research period, countless examples of spaces under viaducts from around the world were shared with us from colleagues within Arup and from our research partners. We have presented a selection of case studies for inspiration on these pages.


9/


10/


11/


12/


13/


14/


15/


16/


17/


18/


19/

9/ Rouse Hill, Sydney ©Transport for New South Wales
10/ Rouse Hill, Sydney ©Transport for New South Wales
11/ Under the Anzac Bridge, Sydney ©NSW Roads and Maritime Services
12/ Albert 'Tibby' Cotter Bridge, Sydney ©Arup
13/ A8ernA, Amsterdam, ©Luuk Kramer
14/ Phoenix Flowers, Glasgow ©7N Architects
15/ Borough Market, London ©Matt Lally, Arup
16/ Taman Film Bandung, Indonesia ©Delly Sudirman
17/ Hungerford Bridge, London ©Matt Lally, Arup
18/ Cross Air Tower, TOkyo ©Clark Parker
19/ Yokohama ©JA+U


20/


21/


22/


23/


24/


25/


26/


27/


28/


29/

20/ Ralambshovsparken Skatepark, Stockholm ©Mikael Kristenson
21/ SEART Sylvia Park, Auckland ©Isthmus
22/ + 23/ Westway, London: Before viaduct transformation (late 1960's), ©Westway Trust
24/ + 25// Westway, London: After viaduct transformation (present), ©Westway Trust
26/ Yokohama ©Google street view
27/ Woolloomooloo, Sydney ©Matt Lally, Arup
28/ Skytrain, Melbourne ©Level Crossing Removal Authority
29/ Skytrain, Melbourne ©Level Crossing Removal Authority

act iv ation

From neglected and derelict, to hustle and bustle

©unsplash

benefits of viaduct activation

Case studies from around the globe demonstrate the potential for activation of the spaces underneath viaducts to deliver a series of social, environmental and economic benefits at local, neighbourhood, corridor and city-wide scales. Often with some ingenuity, spaces can be transformed from being neglected and derelict to highly productive. The benefits accrued may depend on the type of intervention and the intensity of occupation of the space. The following pages illustrate the spectrum-wide range of possibilities.

There is potentially a wide range of beneficiaries who can gain from these improvements:

- *Benefits in immediate vicinity*
  The most immediate benefits can be felt by those that own, lease or develop the **viaduct structure and the spaces underneath**. These include asset owners (usual government authorities) and/or tenants, developers and those with some regulatory responsibility (in relation to maintenance, for example).
- *Neighbourhood benefits*
  Widening out to the **neighbourhood level**, beneficiaries include local residents (benefiting from local connectivity or liveability improvements, for example) and businesses directly benefiting from the occupation of spaces as well as those in the surrounding area that benefit from uplift improvements; and
- *Corridor-wide and city benefits*
  At the **corridor-wide or city level** this includes the city Mayor and government institutions.

The nature of the benefits experienced tends to evolve over time. Sometimes short-term ‘meanwhile uses’ or pop-up activations are introduced, which mature into more permanent uses over the longer term as the viaduct transformation takes place.

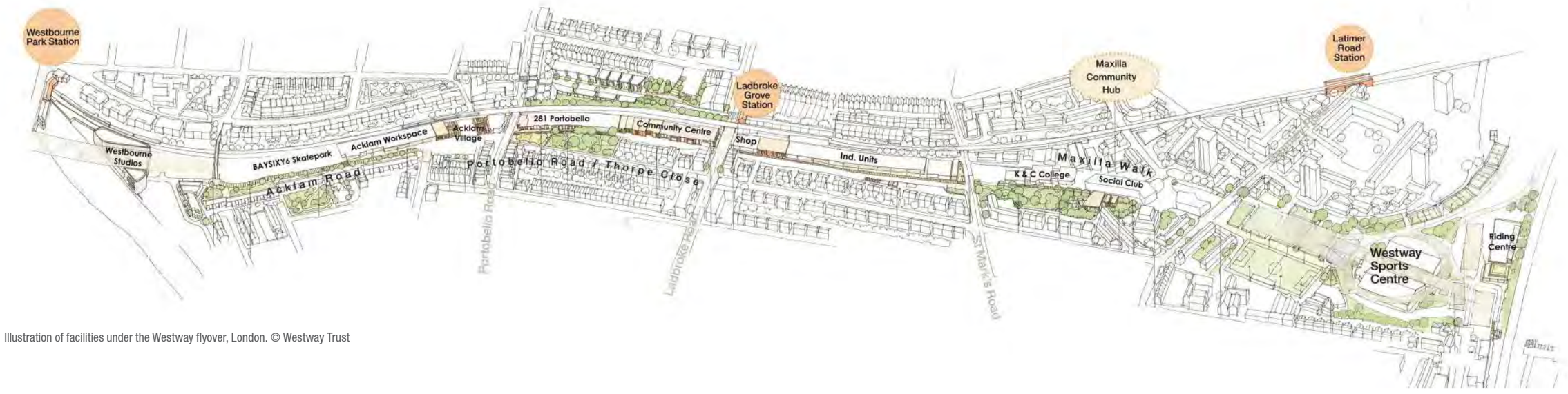


Illustration of facilities under the Westway flyover, London. © Westway Trust

Local benefits experienced in the immediate vicinity

At the local-level, viaduct transformation can generate a series of intrinsic benefits related to the viaduct structure, the spaces underneath and its immediate context.

Amenity

Viaduct activation can create active street frontage. High quality streets and places can raise pride in an area and promote investor confidence.

For example, enhancing laneways in Melbourne with wider footways, more greenery, street art and usable activities has generated a 39 percent increase in pedestrian traffic on weekdays and 98 percent increase on weekday evenings. "The results clearly illustrate that places designed to be people-friendly attract people, and public life will follow[5]."

Sense of place

Interventions that include engagement with the community in the design process present an opportunity to build a community's character and feeling of belonging.

Local connectivity

Reducing severance and increasing links in pedestrian and cycle networks provide the basis for increased walkability and cycling. Enhancing local connectivity has been linked to increased social capital.

An Irish study demonstrates that residents of walkable districts show 80% greater levels of social capital[6].

Economic value

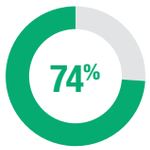
Converting empty, disused and under-used viaduct spaces into bars, cafes, shops or a myriad of other revenue generating uses can create real economic value for the asset owner, more broadly, the introduction of such uses can enhance the vitality and viability of the local economy.

Maintenance savings

Passive surveillance and greater activity near the structure and spaces under the viaduct have the potential to reduce maintenance costs due to reduced vandalism, and can sometimes lead to maintenance costs being transferred from asset owners to the lessees of viaduct spaces.

Safety and security

Unused viaduct spaces can sometimes be a focus for anti-social behaviour. Occupying these spaces with positive uses can alleviate this. At its simplest this can involve creating attractive and well-lit walkways under the viaducts. There is much evidence that walkable environments can naturally aid the prevention of crimes. Lighting can have a major impact on the identity, safety and security of a place.



In Kansas City, crime in Kessler Park dropped by 74% the year that 2.6 miles around it turned car free on weekends.

Making streets cleaner and removing graffiti, contributed to a dramatic reduction in crime over a period of two years: drug crime dropped by 30%, burglary by 22% and vandalism by 31%[7].

Flood mitigation and climate resilience

Measures can be designed-in to enhance local ecology and address potential climate risks of an area, for example through incorporating flood mitigation and anti-heat island effect climate resilience techniques into a structure's design.

The city of Indianapolis implemented the Cultural Trail, an eight mile greenway that diverts over 18 million litres of runoff per year, saving the city funds and resources[8].

Risk reduction

Disused viaduct spaces can pose a significant liability. Liability risks can range from the potential for illegal fires to the risk of hostile vehicle-related terrorism. Occupying the spaces with positive uses can lead to a major reduction of such risks.

5 www.heartfoundation.org.au/images/uploads/publications/Good-for-business.pdf
6 *Making the case for investment in the walking environment: A review of the evidence*, by Danielle Sinnett, Katie Williams, Kiron Chatterjee and Nick Cavill. 2011. UWE. Available from: http://eprints.uwe.ac.uk/15502/.
7 Pedestrian propulsion, by Steve Mouzon. 2009. Original Green. Available from: http://www.originalgreen.org/blog/pedestrian-propulsion.html
8 Indianapolis cultural trail, by US Department of Transportation, Available at: http://contextsensitivesolutions.org/content/case_studies/indianapolis_cultural_trail

Neighbourhood and corridor-wide benefits

At the more strategic scale, benefits can be realised to benefit a neighbourhood, a district or along an entire corridor when addressed comprehensively.

Greater space productivity

Utilising the development potential underneath rail and road structures presents the opportunity to provide public space, new commercial or community premises or recreational/sports facilities, as relevant to the community and locational context. Utilising space efficiently in cities for community uses is becoming increasingly important as land values increase and public providers are increasingly financially strained to create new public open space.

In one study for the City of London, **London's future open-space deficit was projected to be 1100 hectares (ha) by 2031**[9].

Network and place connectivity

Using the space under viaducts for walking and cycling paths presents the opportunity to extend the corridor network of access to open space and connectivity to local services, helping to stitch places and communities together. As a high proportion of all retail comes from local residents and workers, enhancing and extending local connectivity can support local retail viability.

Health and wellbeing

Establishing a corridor-wide walking and cycling network under viaducts and connected to open space, and connecting these into broader area cycling networks presents the opportunity to encourage physical activity. Regular walking has been shown to decrease the risk of type 2 diabetes, coronary heart disease, and stroke – all of which cause mortality.

A study found that those who **walk for more than 8.6 minutes per day are 33% more likely to report better mental health**.[10]

Flood mitigation and climate resilience

Considering permeable surfaces across the length of a viaduct has the potential to reduce runoff and recharge the water table at a corridor level. Greening of urban infrastructure can help to reduce potential heat island effects.

Biodiversity

Integrating nature into the design of spaces under viaducts has the potential to enhance local habitats, and avoid degradation and fragmentation. Understanding the different ecological assets at a corridor level and designing to enhance biodiversity in an area can provide habitat, food and protection to wildlife as well as providing a diversity of plant species in an area.

Contributions to urban forests can help deliver more broad-based healthy ecosystems through regulating urban climate and microclimate, improve air quality, purify water, control stormwater runoff, improve soil fertility and recycle wastes.

Research conducted by Sandström et al[11] in 2006 also identified that perceived **quality of life might improve when the 'fraction' of nature in urban areas increases**. **Natural areas in cities provide the opportunity to directly experience nature** (Miller, 2006). This is considered to be a crucial aspect for restoration in a world with a highly urbanised population (Home et al., 2009a).

Retail, workspace and leisure trading

Combining the design of safe and accessible pathways with contemporary retail and business uses as infill development under viaducts has the potential to support the overall viability of retail and leisure trading and desirability of workspaces.

In corridors with retail and business uses, **enhancing the public realm can boost footfall and trading by up to 40%**[12].

9 https://www.gensler.com/uploads/document/222/file/pr_110307_Open_Space_03_08_2011.pdf
10 *Making the case for investment in the walking environment: A review of the evidence*, by Danielle Sinnett, Katie Williams, Kiron Chatterjee & Nick Cavill. 2011. UWE. Available from: http://eprints.uwe.ac.uk/15502/.
11 Sandström, U.G., Angelstam, P., Mikusinski, G., 2006. Ecological diversity of birds in relation to the structure of urban green space. Landscape Urban PlanSource
12 https://www.livingstreets.org.uk/media/1391/pedestrianpound_fullreport_web.pdf

“64% of people chose the city before the company or the job.”

City-scale benefits

Transformation catalyst

The neighbourhood now familiarly known as Dumbo in Brooklyn, New York, which stands for Down Under the Manhattan Bridge Overpass, is a vivid demonstration of how a coordinated series of interventions (sometimes small in nature, big in impact) can be introduced to demonstrate alternative models of design, delivery and maintenance of space in a time when there increasing budgetary and resource challenges from government[13].

City branding

Aligning the creative use of space with the ambitions of the city has the potential to assert a city’s global brand. There is no better demonstration of this than New York’s High Line, and the elegance of Paris’s Viaduct des Arts is another example. Being able to attract talent to cities through good quality city design forms an important part of a city’s economic development.

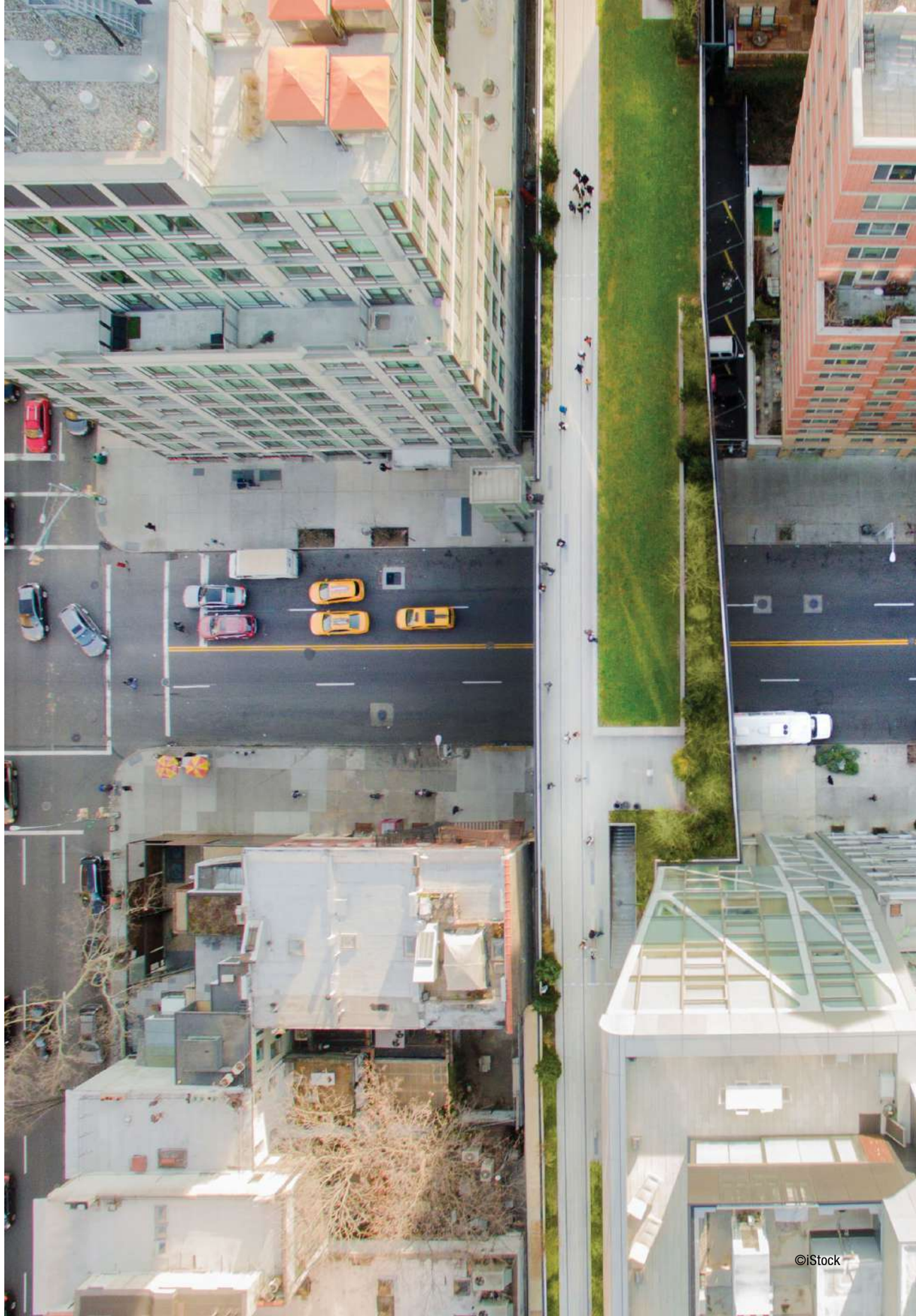
One study suggested that 64% of people chose the city before the company or the job[14].

SME Employment

Infill development that enables occupation of viaduct spaces for creative use (through flexible rental arrangements and reduced rental) has the opportunity to increase employment and boost local small business generation and entrepreneurship.

Dublin’s renewal of the Temple Bar as a vibrant cultural quarter, for example, led to a 300% increase in employment[15] and there are examples abound of creative permanent or ‘meanwhile’ being accommodated under viaducts in a way that completely re-energises a place. The Westway in London, for example, hosts a series of creative and cultural uses including workshops and studios.

13 https://www.nytimes.com/2014/09/21/realestate/transforming-a-brooklyn-neighborhood-with-new-condos.html and http://www.nydailynews.com/life-style/real-estate/dumbo-brooklyn-neighborhood-wasteland-urban-wonderland-article-1.190779
14 Cited in https://hbr.org/2010/05/back-to-the-city
15 https://www.livingstreets.org.uk/media/1391/pedestrianpound_fullreport_web.pdf



possi bil itie s

Real-world projects with powerful potential

©iStock

Design investigations

A process of enquiry by design

Having categorised different types of viaduct for investigation, a series of design exercises were undertaken to explore how viaduct spaces could potentially be better utilised in a variety of different locations and contextual circumstances. This enabled the team to delve deeper, to address the potential technical issues and opportunities that present themselves, and to find creative ways of addressing these through a process of 'enquiry by design'.

Eight projects were identified for detailed investigation. As indicated in the table opposite, these covered the spread of different viaduct typologies. They also represent different stages in project evolution.

Personnel from five Arup offices were involved in these examinations and investigations (Sydney, Melbourne, London, Johannesburg and New York), working with local stakeholder organisations in each location.

The Westway
Elevated Highway + Highway Junction

Built, activated and constantly evolving

A variety of facilities in the viaduct undercroft spaces have been introduced over many years, and the Westway Trust is looking at what further improvements can be made

The Harbour Bridge Bays
Bridge Ramp Undercroft

Built and activated

Conversion recently completed and provides an excellent demonstrator

M4 Expressway
Elevated Highway

Existing viaduct with potential

At present viaduct spaces are under-utilised. Our research signals how this could change

New York Subway
Elevated Rail (Metro)

Existing viaduct with temporary pilot projects

The Design Trust for Public Space has implemented a series of temporary pilot projects and is exploring how this momentum can be built on

Addis Ababa Light Rail Train
Elevated Rail (LRT)

Existing viaduct with potential

Our research signals how unused viaduct under-spaces could be put to productive use

Westgate Freeway
Elevated Highway

Existing viaduct with potential

Our research signals how better user of the viaduct undercrofts could have a major city-shaping impact

Sydney Skytrain
Elevated Rail (Metro)

Under construction and planning viaduct activation

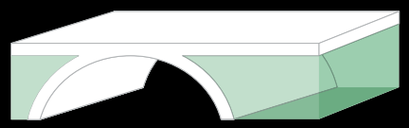
Sydney's Skytrain stretch of elevated metro line is under construction. Government authorities are currently planning activation interventions

The Harbour Bridge Viaduct Bays

Restoration and conversion of a neglected heritage asset

SYDNEY

BRIDGE RAMP UNDERCROFT



Overview

In 2016, as part of the New South Wales (NSW) Government's Office Relocation Program, Roads and Maritime Services (RMS) staff were relocated out of leased premises in the North Sydney Central Business District into the RMS-owned transformed undercroft spaces located underneath the ramp to the Sydney Harbour Bridge. This was a bold move and has proven to be an outstanding success.

Upon opening in 1932, the original ramped structure comprised a skeletal frame, which exposed the void spaces to Ennis Road. A facade was later added in the art deco style favoured at the time that enabled the spaces behind this street frontage to be put to productive use, including retail and office functions. However, these spaces proved unattractive and over the years fell into disrepair – leading to them coming to be known disparagingly as "the Harbour Bridge dungeon" and "the Bradfield Bunker" (after Harbour Bridge engineer)[16].

In 2016, twelve former tenancy spaces were consolidated together as part of a major refurbishment and conversion project that involved significant structural modifications to the bridge piers, wholesale replacement of existing services, the construction of an internal roof and drainage system, reconstruction of suspended timber floors, the introduction of a secondary glazing system and an internal fit out that has been executed to an excellent standard.

The resulting 4,000m² office space is accommodated over two levels and forms a characterful sequence of intriguing spaces that unites 11 bays (bridge pier to bridge pier) on the ground floor and 13 bays at the upper level.

Above: Prior to refurbishment, many of the spaces were in poor condition and under-utilised (Pictures: © Virgina Young, The Daily Telegraph)
Below: Upon opening, the Harbour Bridge had an exposed skeletal frame, image courtesy of ©NSW Roads and Maritime Services

16 http://www.dailytelegraph.com.au/news/nsw/harbour-bridge-dungeon-will-be-the-new-home-for-roads-and-maritime-services-bureaucrats/news-story/e83d45974bb0bf27f45fd09d1775928c

Design insights

Designs have served to realise the following benefits:

- Encapsulation of each bay to protect from dust water and poor air quality
- The low-level building with stairways promotes more walking and activity
- The character and layout of the building, the light spaces and the views of the landscape promotes interaction and a feeling of well-being
- Green walls are expensive to maintain but they freshen the space, improve air quality and are popular with staff. The walls now are home to a native species of frog!
- The piers and the openings (which do not line up) create an interesting organic sequence of spaces
- In summer the overhead sun and heat is absorbed by the dense, thick bridge superstructure

Design learnings

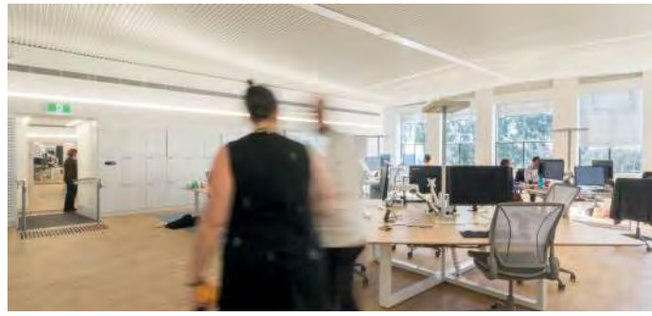
Lessons to be drawn for designing-in accommodation into new build viaducts, or potential similar conversion opportunities include:

- Ensure ample room under viaducts to provide space for the building (in this case accommodation over two levels) and room for ongoing inspection of the viaduct soffit
- Piers should be designed with openings so that future openings are not needed to be cut
- Bridge joints should not coincide with buildings below. The traffic noise is shielded by the bridge deck but the joint vibration travels through the structure
- An urban design approach drawing together architects, engineers and heritage experts leads to the creation of high quality space and an exemplary outcome

Benefits

The refurbishment and conversion work has resulted in:

- Office accommodation for over 250 people that has been built to excellent design and environmental standards, and provides a generous amount of highly attractive space for its occupants
- The conservation and revitalisation of a much-loved heritage structure
- A net saving to Government – with RMS no longer having to pay rent to a third party
- Value creation – turning a former liability into a major asset
- The reduction of safety and security risks associated with tenancies and potentially vulnerable unused spaces



Above: The art deco facade has been restored to its original glory; a the series of inter-linked internal workspaces. Below: The reception area, complete with green wall.

Images: ©NSW Roads and Maritime Services

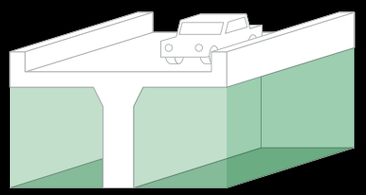
Above: cycle parking facilities ©NSW Roads and Maritime Services

Westway London

A strategic community-based approach to activation, reinvention and renewal

LONDON

ELEVATED HIGHWAYS



HIGHWAY JUNCTION

Overview

Following construction of the overhead motorway (the A40(M)) through the North Kensington area of London in the mid-1960's, a four-year community campaign seeking compensation for the impact ensued. Consequently, the North Kensington Amenity Trust was set up in 1971 (since renamed the Westway Trust) in partnership with the local authority. The new body was established as one of the UK's first social enterprises to act as custodian of the 23 acres (9.5 hectares) of land underneath and either side of the highway in promoting the positive use of the viaduct spaces, a role it has fulfilled ever since.

Over the proceeding years, a mile-long series of community and commercial facilities have been established, including 120 businesses, including offices for charities, independent retailers and workshops for a variety of enterprises. It hosts a lively market and events space, and the Westway Sports & Fitness Centre incorporates a highly popular gym and indoor climbing wall, and extensive outdoor facilities, including football pitches, tennis courts, cricket nets, basketball courts and netball facilities.

Run as a charity, the Board of Trustees is made up of people from a diverse range of backgrounds, elected by the Trusts's Member Organisations to serve the community, ranging from community groups and residents' associations to schools and sports clubs.

Independent from the Westway Trust but located immediately adjacent to the north, Westbourne Studios also provides a highly successful example of a converted viaduct undercroft, built as a managed workspace for creative industries and artists.

Community challenges

The North Kensington area within which Westway is located has a very mixed population in terms of both socio-economic background and ethnic diversity. Located within one of London's most wealthy boroughs, the social polarity between the area's 'haves' and 'have nots' was thrown into sharp relief by the issues surrounding the 2017 Grenfell Tower fire tragedy, which has served to highlight locally-held perception of gentrification and mistrust for authority. The activities of the Westway Trust are framed in relation to addressing key community challenges, which are described as:

- Housing affordability
- Child poverty and social polarisation
- Space available for community use
- Lack of youth activities and engagement
- Achieving health and wellbeing outcomes
- Air pollution – with some 96,000 cars passing over the Westway each day

Summary of benefits

Spaces under the Westway have proven to be extremely popular for a wide range of occupiers and their users – indeed 96% of the spaces provided are occupied, with plans currently being developed to provide further facilities and renew others, together with adjacent open spaces within the corridor. The breadth of benefits that have been achieved with Westway Trust's approach to community-led development are summarised on the right.

Economic wellbeing and learning

- Enable enterprises to thrive
- Create jobs and apprenticeships
- Offer training and mentoring
- Encourage visitors
- Support local entrepreneurs and businesses
- Create space for enterprises

Health and wellbeing

- Encourage physical activity
- Enable healthy behaviours
- Tackle childhood obesity
- Create new sports and fitness facilities

Arts, heritage and culture

- Provide space for arts and culture
- Grants to support community action
- Celebrate local heritage and culture
- Reflect community diversity
- Support a thriving voluntary sector

Environment

- Involve community in creating cleaner, greener estate
- Reduce the effects of pollution
- Protect green and open spaces
- Involve environmental sustainability of the estate

Stewardship

- Investment in the estate and facilities
- Effective management of the property portfolio
- Maximising community return from the estate
- Manage future development
- Promote the place

These benefits are felt at a range of scales:

1. Benefits in the immediate vicinity

Following significant public backlash during the introduction of the highway, the occupation of space under the viaduct provides productive use of the structure's undercroft spaces and adjacent footpaths and open spaces are integrated into surrounding networks.

2. Neighbourhood benefits

The Westway Trust is fundamentally community-led in its constitution and approach, resulting in facilities that specifically address local needs, including:

- Sports and recreation facilities that provide space for active and wellbeing outcomes for adjacent communities
- Spaces occupied by artists, which continue to support the creative community in the area
- Spaces for small businesses
- A cultural and community centre

3. Corridor-wide benefits

Open space and parkland creates much valued intern-linked 'green infrastructure' that enhances community connections along the corridor, providing education opportunities for valuing and nurturing green spaces and supporting cleaner air in the area.

4. City – wide benefits

Over the years, the Westway has grown into a London destination with an established reputation for sports, cultural, creative and community expression.

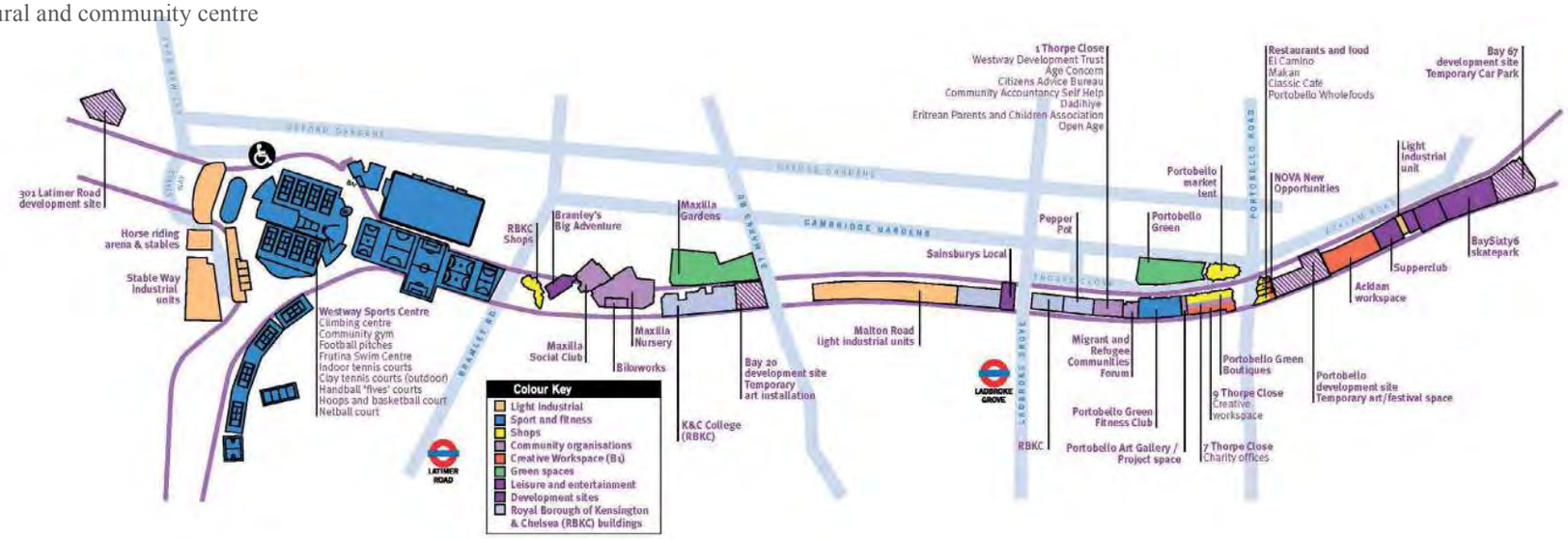


Illustration: ©Westway Trust

Design features

There is a diversity of offerings under the Westway along its mile-long length, including (from west to east):

Westway Sports & Fitness Centre located at the western end is a highly popular sports hub, which includes a series of sports facilities located, rather audaciously, in the middle of an the expansive highway junction. These provide a steady income for the Westway Trust that enable the facilities to be available for local use at discounted rates, supporting active community and wellbeing objectives.

A cluster of retail and enterprise units, a college and nursery provide a vibrant mixture of facilities. Several of these units are offered at flexible rental arrangements, enabling small businesses to be hosted. A workspace hub supports smaller entrepreneurial businesses such as pottery, pilates studios and kitchen showroom.

A series of business offer local services within the central section, including builders, merchants, plumbers and motor mechanics.

A former nightclub, currently vacant, is being considered for alternative potential community use.

- *A market-place* forms part of the Portobello Road market, one of London's most popular destinations. A new project ('Portobello Village') is currently proposed by the Westway Trust, which includes:

  - An arts and cultural centre on Acklam Road for year-round events including film screenings, live music, theatre, arts workshops and exhibitions.

  - A New shopping arcade under the Westway flyover designed as an indoor market hall.

  - A New stage and grass area for performances and children's play area at Portobello Green.

  - The Acklam car park redeveloped to host independent retailers and 13 affordable one to three bedroom flats.

- *The Bay Sixty 6* skatepark occupies space at the eastern end, and hosts a series of events, skate camps and lessons. Bay Sixty 6 as an organisation seeks to benefit the surrounding community through sport by engaging with local youth, enabling personal improvement, camaraderie and mentoring through learning and camp programs.

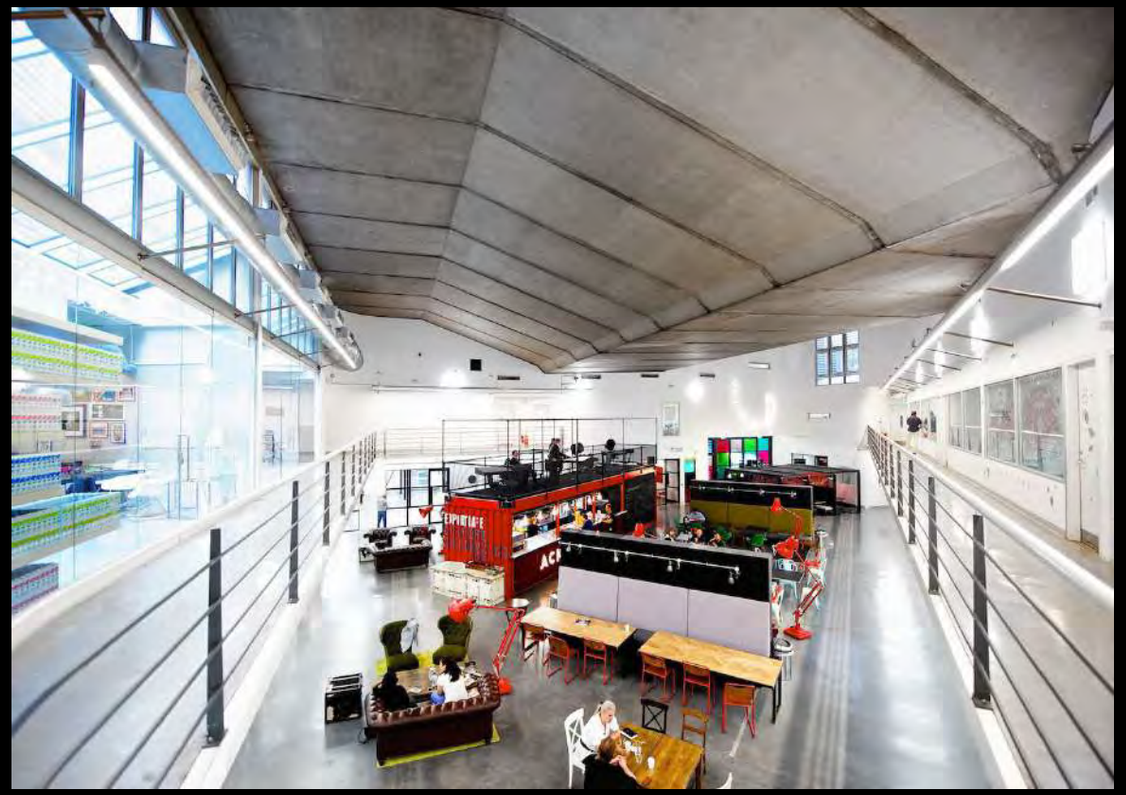
The Westway Trust was established in 1971 in response to building a motorway through the community

Today Westway accommodates a wide variety of uses

Images: ©Westway Trust (all)

Above: Two medium-rise blocks protrude either side of the carriageway. Below: Between these blocks an elegant multi-functional space forms the focal point, with the exposed concrete under-side of the viaduct structure forming a distinctive ceiling

Images: Top: ©Google street view. Bottom: ©Interior Integration Solutions Ltd. Opposite page: ©Interior Integration Solutions Ltd (all)



Above: Between these blocks an elegant multi-functional space forms the focal point, with the exposed concrete under-side of the viaduct structure forming a distinctive ceiling
Below: The central space is framed by a series of artist and office studios, and activated by a cafe/bar

Westbourne Studios

Although not part of the Westway Trust's property estate, Westbourne Studio, located to the immediate east underneath the same overhead motorway structure, is a remarkable example of what can achieved within a viaduct space with verve and imagination. A managed workspace, accommodating a diversity of office studios with approximately 100 work spaces, has been created that involves two towers, protruding either side of the elevated structure, linked by a covered courtyard underneath. The courtyard contains a cafe and bar, together with a flexible space that variously serves as an art gallery, a screening room and an exhibition space. It has even functioned as a nightclub and opera venue.

Glazing either side of the structure ensures that it generously lit, with the exposed concrete underside of the viaduct structure providing an elegant ceiling to the courtyard space.

Lessons in design

A corridor to connect communities

A major driver for the Westway Trust is to improve social mixing and attachment to the area, to celebrate the area's diversity. This focus on inclusivity and authenticity is considered critical given the area's ethnic diversity, the variation in economic incomes and the significant development pressures being experienced in the area. The over-arching intention is to create a community ecosystem that provides positive outcomes and filling gaps in local community service provision through both activities and spaces.

The Westway has provided a platform for activism in the area through a series of engagement activities hosted by the Trust. For example, the Trust is supporting survivors and relatives of the Grenfell disaster to have access to flexible space for the local community and to campaign on behalf of local people for a legacy to the area.

There are existing green elements throughout the Westway that provide a further foundation for connecting communities physically through the landscape, and providing greater connections to green space.

The activities hosted in the infill spaces of the Westway viaduct (festivals and learning activities) help to provide spaces for people to come together across the corridor. A number of programs are designed by the Trust to better connect people and business. For example, 'Creative Futures' aims to support local employers within the creative industries to develop high quality, entry level, employment opportunities for local young people. The next phase in the area's evolution is to establish activity-based and physical connections with the new campus of the world-renowned Imperial College being developed immediately to the west (also in part under the Westway flyover).

Design of facilities respond to form and community context

The Westway has a number of physical challenges:

- Poor permeability due to the physical barrier road structure
- Lack of light
- Air and noise pollution
- Variations in height
- Restrictions on attachments to the Westway structure.

Design of infill of the Westway viaduct requires careful consideration in relation to these constraints. For example, the elevated circular junction, a significant urban structure, has successfully accommodated the sports facilities underneath. Other uses, such as offices, business and open space, were designed throughout the corridor in relation to the height of the space and connectivity to surrounding context.

Appropriate occupation is a constant evolution

Determining the most appropriate facilities to be accommodated under the Westway, in relation to the varied nature and configuration of spaces on offer is constantly evolving. The challenges of the space require creative response to consider, in the community and locational context, what may be the most appropriate use of the space.

Spaces that are quite large require larger organisations to occupy and support. Spaces that have since become vacant, such as the nightclub, are being reviewed for alternative community use.

The challenge for future use is that activities need to be fit for occupation and meet requirements for health and safety. Activities and uses are also required to address commercial considerations. This requires a balance of what is wanted by the local community, an activity or space that is contributing something new in the area, and that has an income stream. This is often challenging to balance with spatial constraints and a diverse community with diverse political views.

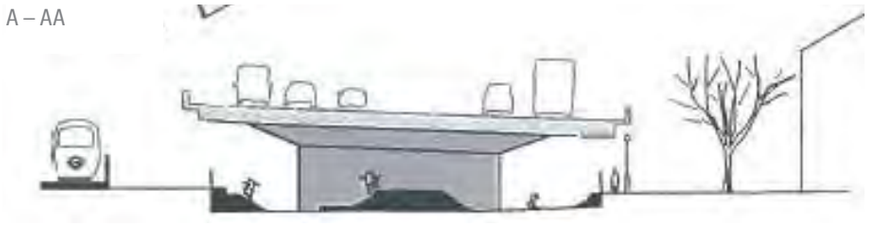
Lessons in process

Deep and deliberate engagement with the community

From its history as a location of public protest, the Westway Trust continues to promote inclusive planning for the surrounding communities it serves. New proposals for the occupation under the Westway attract significant interest from the community, member organisations and business people. The Westway Trust undertakes deep and deliberate engagement with the community on each new initiative. This includes hosting tea sessions for discussions for sharing information, using market stalls at the Portobello Markets, and for some schemes such as the Portobello Village, the length of consultation period is one year.

Continued engagement with government

The Westway Trust has a long lease with Transport for London for occupation under the Westway. There are provisions within their lease that protect the Westway structure. The Trust has a strong relationship with Transport for London as the organisation understands the history of the site, and the importance of continued support related to corporate social responsibility.



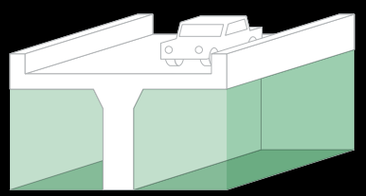
Illustrations: ©Westway Trust (all)

M4 Expressway

Linking Western Sydney's priority regeneration areas

SYDNEY

ELEVATED HIGHWAYS



Overview

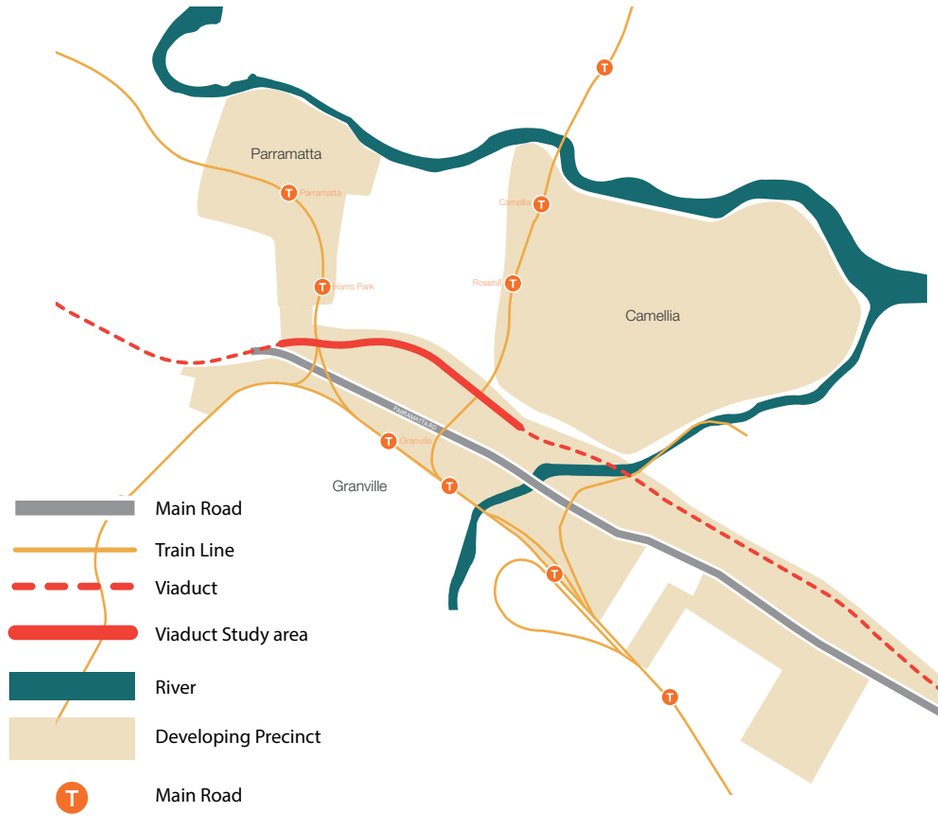
The M4 expressway is Sydney's principal east-west route, connecting the Central Sydney Central Business District (CBD) and Parramatta City Centre. The focal area for the design investigation is located approximately 15km to the west of the Sydney CBD and comprises a 1.5km long stretch of viaduct that is eight lanes wide, resulting in a vast, cavernous, under-utilised undercroft space.

The project site sits astride three regeneration areas:

1. It forms part of the Granville Transformation Precinct (an area targeted for renewal within the Parramatta Road Corridor connecting the two city centres);
2. It interconnects with Parramatta City Centre to the west (adjacent to the 'Auto Alley' redevelopment area, an area characterised by car showrooms and garages identified for change); and
3. Camellia Priority Precinct, an area identified for growth and intensification.

At present, in perceptual and actual physical terms each of these three areas is poorly connected. This theoretical design exercise seeks to challenge the status quo by demonstrating how with some imagination and ingenuity, over time better utilisation of the expressway undercroft spaces could connect, consolidate and transform these areas for people, not just for motorised vehicles.

This case study demonstrates how under viaduct land uses can change over time. Initially uses for active transport recreation and artwork can be cost effective and help improve the security and value of these spaces. In the longer term, (given that bridges are designed for 100+ year lives), land use pressures can help create the economic case for more building type uses to be inserted into the viaduct spaces.



Images: © Matt Lally, Arup

Urban context

The viaduct is located within a primarily residential suburban land use context, somewhat visually blighting the area.
To the south, a mixed-use commercial and light industrial corridor stretches along Parramatta Road.

Within this corridor, Granville Town Centre is well serviced by public transport, and is identified by the NSW Government's Urban Growth NSW Development Corporation as having high potential for social and economic transformation. Granville Station is located 10 minutes-walk (800m) from the viaduct area under consideration, from which there is a 23 minute journey to/from Central Sydney. Harris Park and Rosehill stations are also within close proximity, and bus networks run throughout the area.

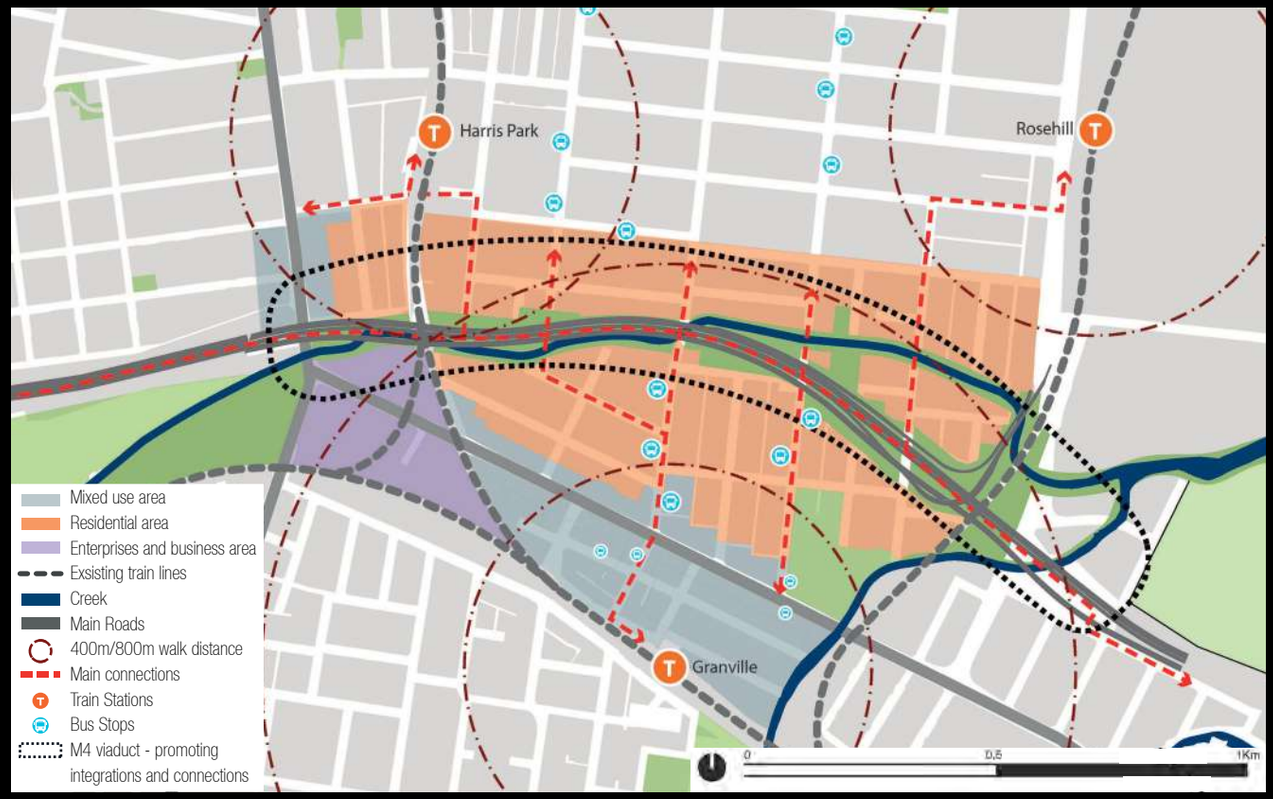
A pedestrian and cycle link extends underneath the viaduct, in part alongside the A'Becketts Creek, a small tributary in concrete channel, lined by small green open spaces.

30/ In places, attractive greenery lines the undercroft edge
31/ Low-density employment premises alongside the train station, ranville Transformation Precinct
32/ The pedestrian and cycle route
33/ The pilot site - where Good Street crosses A'Becketts Creek

30/

31/

32/



33/

Images: ©Arup (all)

Opportunities

Although the area within which the viaduct is located is targeted for urban renewal, consideration of the potential for transformation of the spaces underneath the viaduct itself tends to be ignored – a plan-making blind spot.

We suggest that there are three complementary aspects that should be considered as part of an integrated approach to urban design:

1. Enhancing community pedestrian and cycle route connections

The longitudinal route east-west – already reasonably well-used – could be further improved to connect a network of inter-linking community activity areas.

Lateral connections between communities flanking the viaduct could also be further improved to help stitch these places together and overcome some of the existing severance. In the process, Crime Prevention Through Environmental Design (CPTED) principles related to safe, well-lit routes with good signposting could be applied.

2. Restoring the Creek as a recreational and biodiversity resource

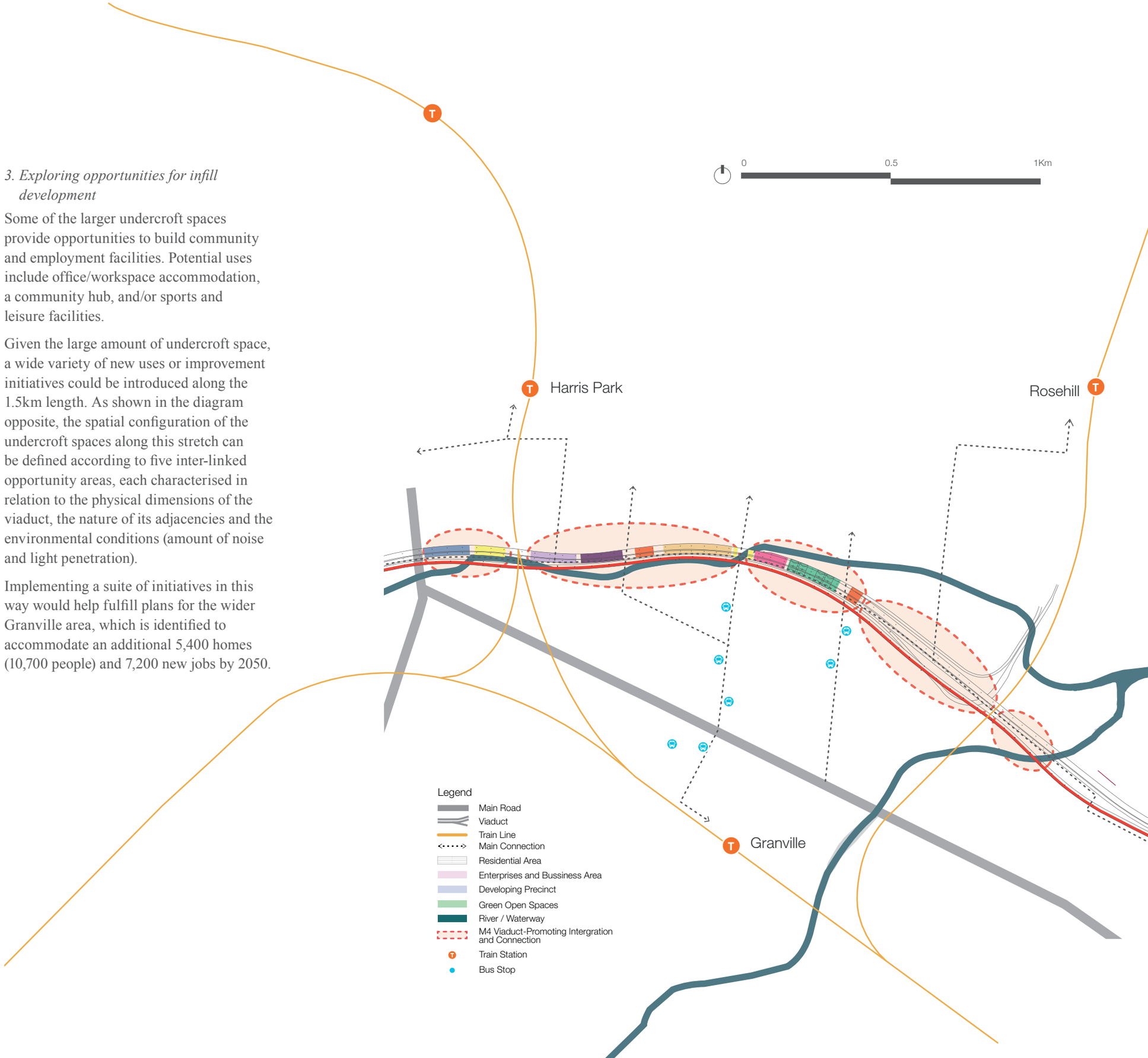
This would form part of a wider strategy being pursued by Government authorities to enhance Sydney's Green Grid of interconnected open spaces. The creek could be naturalised to become a major visual, ecological and leisure asset, as well as fulfilling a sustainable urban drainage function.

3. Exploring opportunities for infill development

Some of the larger undercroft spaces provide opportunities to build community and employment facilities. Potential uses include office/workspace accommodation, a community hub, and/or sports and leisure facilities.

Given the large amount of undercroft space, a wide variety of new uses or improvement initiatives could be introduced along the 1.5km length. As shown in the diagram opposite, the spatial configuration of the undercroft spaces along this stretch can be defined according to five inter-linked opportunity areas, each characterised in relation to the physical dimensions of the viaduct, the nature of its adjacencies and the environmental conditions (amount of noise and light penetration).

Implementing a suite of initiatives in this way would help fulfill plans for the wider Granville area, which is identified to accommodate an additional 5,400 homes (10,700 people) and 7,200 new jobs by 2050.



Design concept

An initial theoretical sample design exercise was undertaken for the 'Central Creekside' area. The site's accessibility make it suitable for a high quality workspace. The combination of a short walk to Granville town centre, the train station and nearby bus stops, together with good cycleway connections, mean that this site would provide a good location for a workspace embedded within an enhanced landscape context.

As the sequence of illustrations opposite convey, this new facility could be designed to take full advantage of the brook-side setting.

Given that this site contains highly contaminated land, the significant amelioration cost is likely to outstrip the benefits of introducing buildings into the viaduct structure in this way in the short term. However, as landscape, active transport, sustainable drainage and public art-related enhancements of the viaduct spaces are introduced progressively as part of a wider regeneration strategy for change, over the medium-longer term the potential conversion potential of these spaces for built accommodation should be given serious consideration.

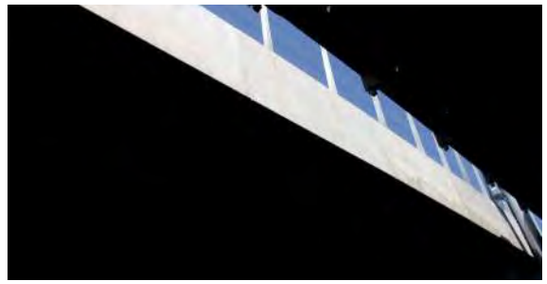
Below: The Aspire artwork of glowing golden trees beneath the Western Distributor in Sydney (www.cityartsydney.com.au/artwork/aspire/)
Image: ©City of Sydney, Paul Patterson

Benefits

Potential benefits to be realised can be summarised as:

- Contributing the wider regeneration of Western Sydney – helping to inter-connect and consolidate the Granville Transformation Precinct (and related Parramatta Road Corridor improvements), the growth of Parramatta City Centre and renewal of the Camellia Priority Precinct. Transformation of the viaduct under-spaces could provide the 'glue' that binds these together.
- Enhanced pedestrian and cycle connections, both east-west and north-south.
- Restoring the Creek as part of a strategic Green Grid approach to making the most of 'Green Infrastructure' that includes sustainable drainage, recreation and biodiversity considerations.
- Potentially introducing new community and / or employment facilities as infill development.
- Potentially introducing public artworks that celebrate local community.

Images: ©Arup

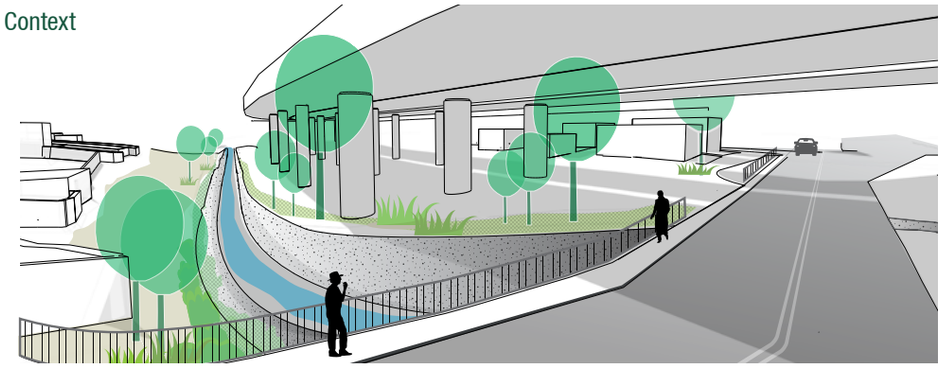


Left: A distinctive shaft of light projects penetrates between the parallel viaduct structures, projecting onto the brook below – an attractive feature to be exploited.

The site is a 10 minute walk from Granville station

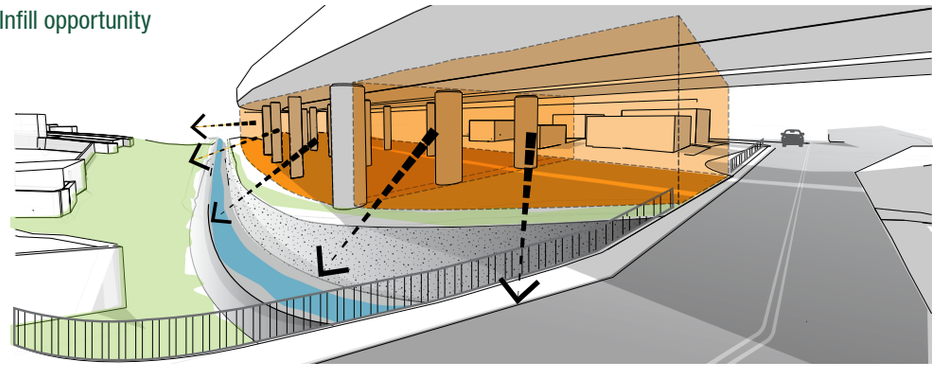
Access orientation

Context



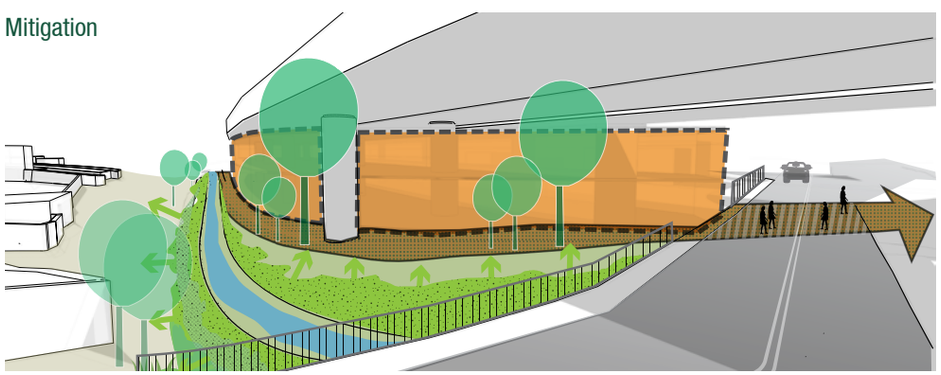
Presently in a concrete channel, the brook forms a potentially attractive feature to be exploited, and the road provides a visual ‘front door’.

Infill opportunity



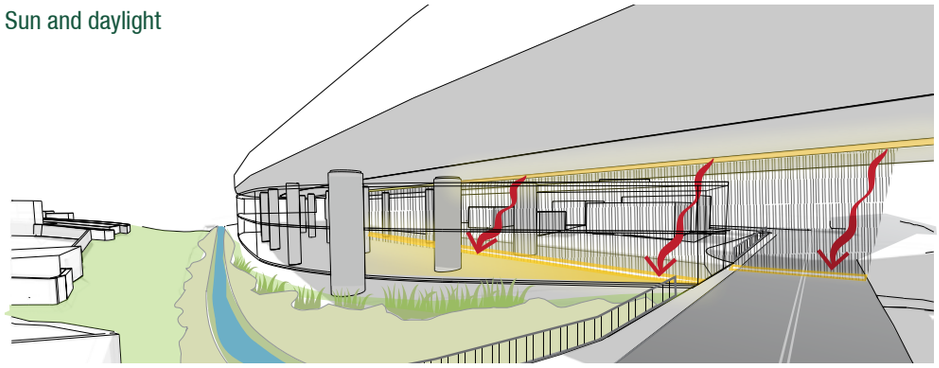
The undercroft space is infilled with a building orientated towards an attractively re-landscaped brookside.

Mitigation



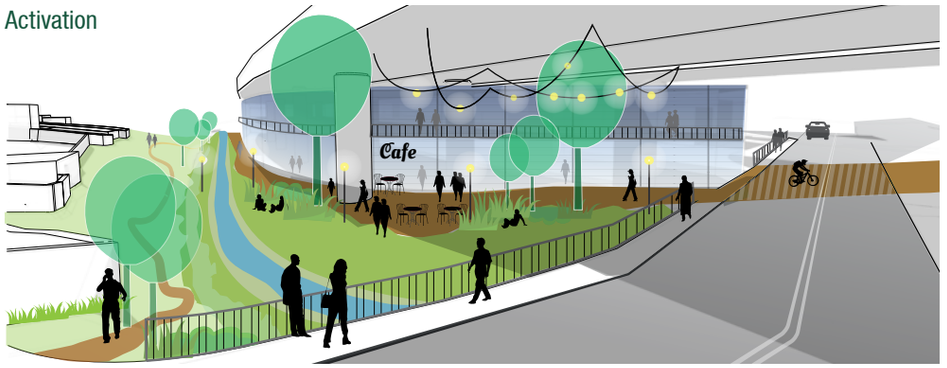
Naturalising the brook forms part of a wider sustainable urban drainage strategy.

Sun and daylight



Architectural design takes advantage of the solar penetration between the two adjacent viaducts with an attractive atrium. Glazing along the riverside maximises daylighting and facilitates attractive views.

Activation



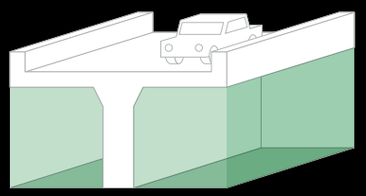
A welcoming main entrance to an attractive workspace building is projected to the street, potentially with a cafe orientated to the waterside. Parkland extends along the brook, with footpath and cycleway.

Westgate Freeway

Opening up Melbourne's riverside

MELBOURNE

ELEVATED HIGHWAYS



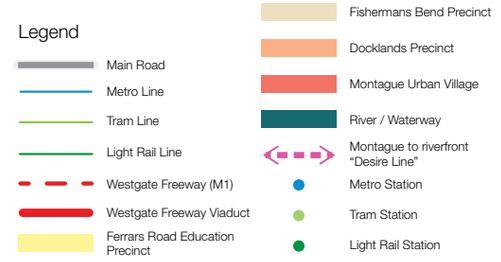
Overview

The Westgate Freeway (M1) extends east-west through the southern side of central Melbourne.

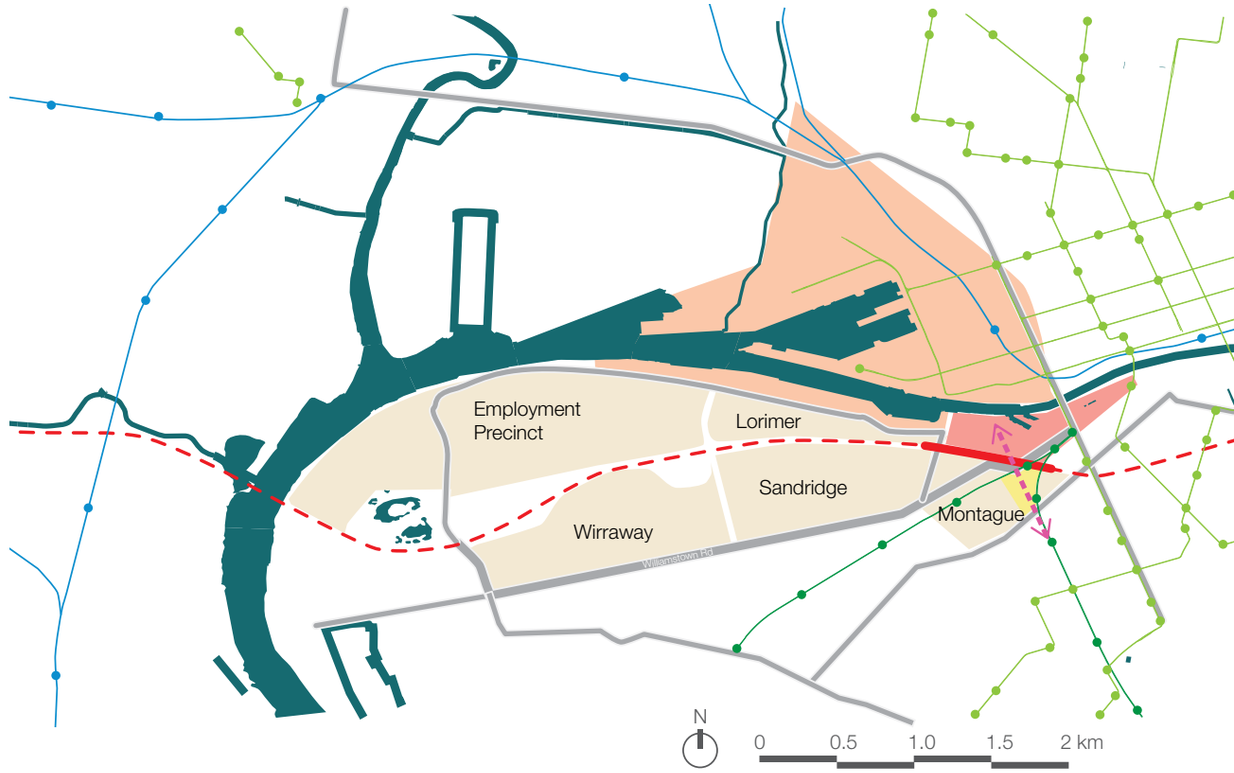
The freeway dissects the area that extends from the southern banks of the Yarra River known as Fishermans Bend. Once thriving docks and associated industry, Fishermans Bend now constitutes the largest urban renewal area in Australia and is made up of five precincts[17]. Together with Docklands north of this, Plan Melbourne identifies these areas as a key to delivering an expanded central city.

This design exercise focuses on a stretch of viaduct approximately 750m in length, which forms part of a highway junction system and comprises 15 lanes in places.

The viaduct severs the area identified as Montague Urban Village[18] (which itself contains the Ferrars Road Education Precinct centred on plans for a new primary school, integrated community facilities and public realm improvements) from the Yarra river and Docklands beyond. Stretched along the Yarra riverside, the Convention Centre and associated entertainment and leisure complex provides a major destination, yet the freeway serves to cut off this major activity hub from its hinterland, and prevent each of the areas identified for major renewal investment from being connected and consolidated at ground level.



The viaduct currently poses a major visual eyesore and pedestrian barrier to the riverside and central Melbourne beyond. Image: ©Google street view.



17 Fishermans bend Recast Vision (http://haveyoursay.delwp.vic.gov.au/Fishermans-Bend-Documents)
18 Fishermans Bend Strategic Framework Plan (2016 update) (http://haveyoursay.delwp.vic.gov.au/Fishermans-Bend-Documents)

Opportunities

The design exercise begins by establishing a framework for opening up opportunities, namely:

- the pedestrian 'desire lines' that could serve to stitch the area together if created and reinforced; and
- the viaduct undercroft space and adjacent under-utilised land that could be targeted to help deliver the area's transformation.

Two potential major bisecting pedestrian routes are identified:

- a north-south route that extends between the Ferrars Street Education and Community Precinct and the nearby tram stop, passing through the Convention Centre car park to the riverfront and onwards to Docklands. Though possible to achieve on foot, this route is presently unsafe, unattractive and uninviting; and
- an east-west route that extends from Munro Street (within Montague Urban Village) to the Convention Centre and riverfront, which continues onwards to the Melbourne Sealife Aquarium. The connection alongside the Convention Centre building is inaccessible at present but could be achieved with some building modification.

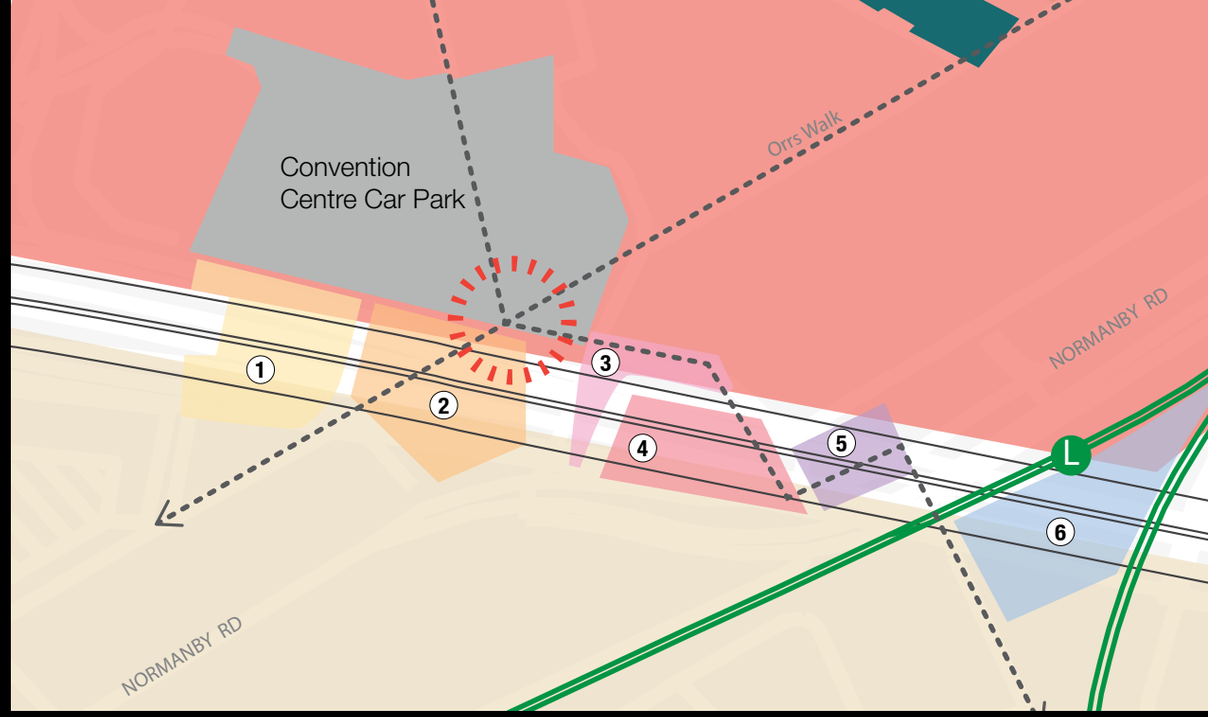
Both these routes intersect at the Convention Centre car park, currently an unattractive, single-story raised deck structure.

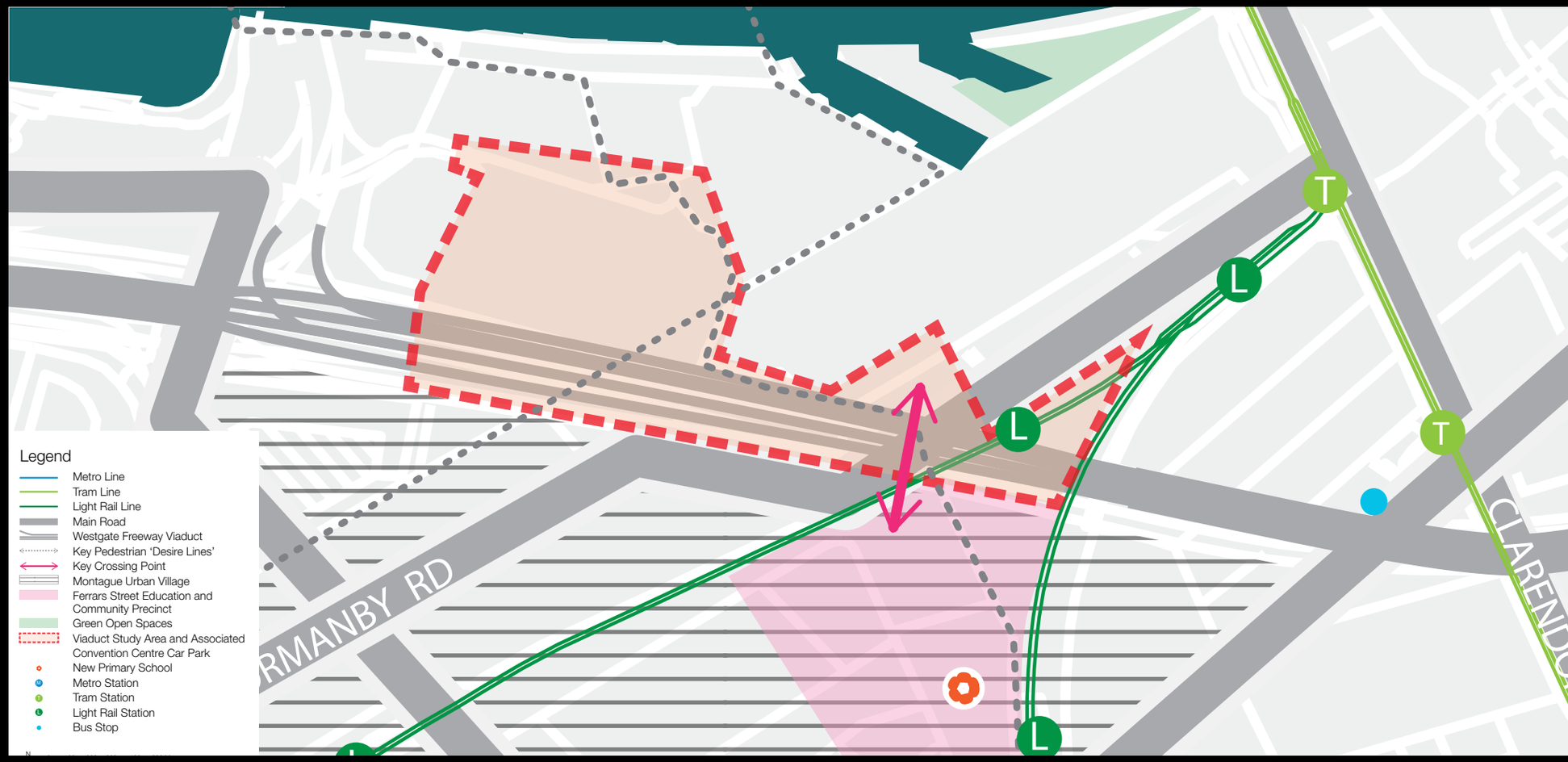
The car park is proposed to be redeveloped as part of plans for the Convention Centre's expansion[19].

19 See http://mcec.com.au/expansion/news-and-resources/

A close look under the viaduct

The viaduct spans over six separate sites that should be considered for inter-related improvement initiatives. Sites 1 and 2 provide the largest opportunities, and are currently used for car parking. Sites 3, 4 and 5 are all hard surfaced residual land. Site 6 is comprised of 'left over space' alongside the tram stop that is under-utilised.





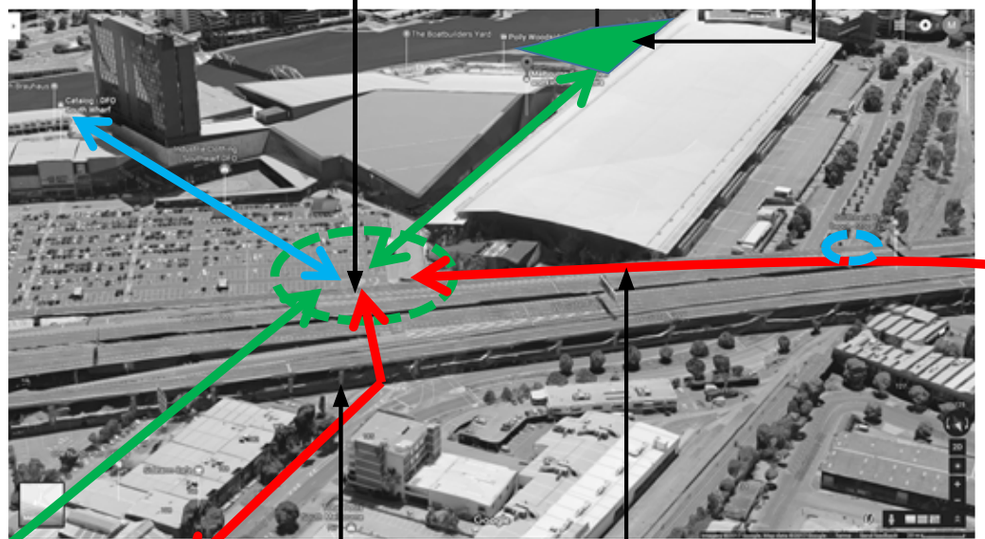
Concept

The design concept is to open up safe and attractive pedestrian connections and create infill development that is orientated onto a major new open space plaza, delivered as part of the Convention Centre's expansion.

34/ Sites 1 and 2 and car park hub location
35/ Space between Convention Centre buildings
36/ Southern interface
37/ Sites 4 and 5

34/

35/



36/

37/

A new hub is proposed where key pedestrian routes intersect. Images: 34/ ©Google street view, 35/ 36/ 37/ ©Arup

Benefits

Potential benefits to be realised can be summarised as:

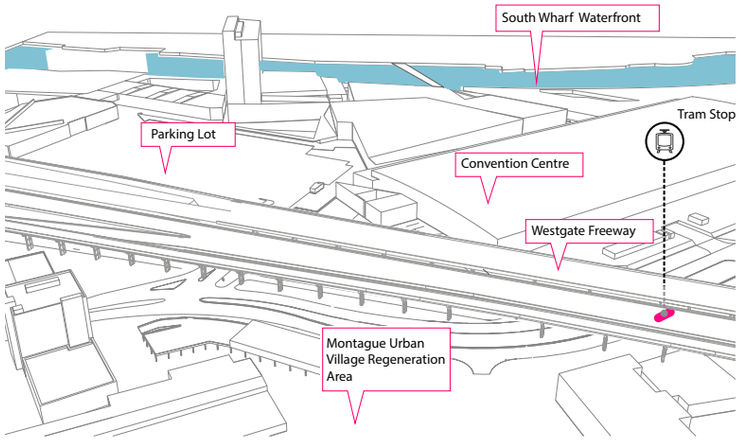
Creating high quality, direct pedestrian connections that stitch together the hitherto fragmented areas for urban renewal and public investment within the Fishermans Bend regeneration area. New well-lit and landscaped routes, lined by active frontage wherever possible, would inter-link:

- The Montague Urban Village and Ferrars Road Education Village to the south (and adjacent areas)
- The tram stop
- The Convention Centre and riverfront entertainment and leisure complex
- The Docklands area and city centre beyond to the north
- Helping to facilitate expansion of the Convention Centre in a way that extends into the under-spaces of the viaduct – enlivening these with uses that project active frontage, creating new positive public spaces and strengthening this as a destination.
- Diversifying the mix of uses, creating more fine-grained uses that broadens the offer, enhances riverside activation and provides opportunities for local enterprises. These could include a collection of small independent cafes, bars, restaurants, independent retailers and workshops to complement the existing larger-format uses.
- Creating income-generating spaces of value in the undercrofts that could potentially be aimed at encouraging local small enterprise and job creation.
- Establishing a new focal point, a lively public space of broad appeal.

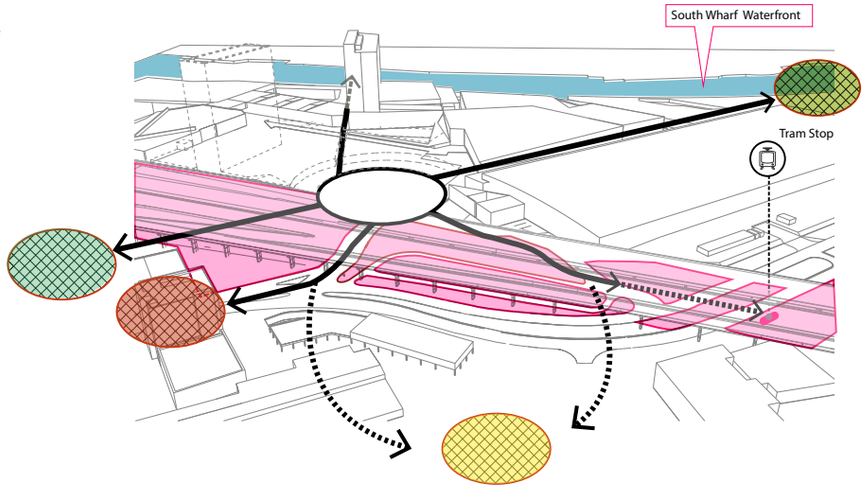
Design Strategy

These illustrations convey the overall design strategy, which aims to stitch together and consolidat the area's assets.

1/



2/



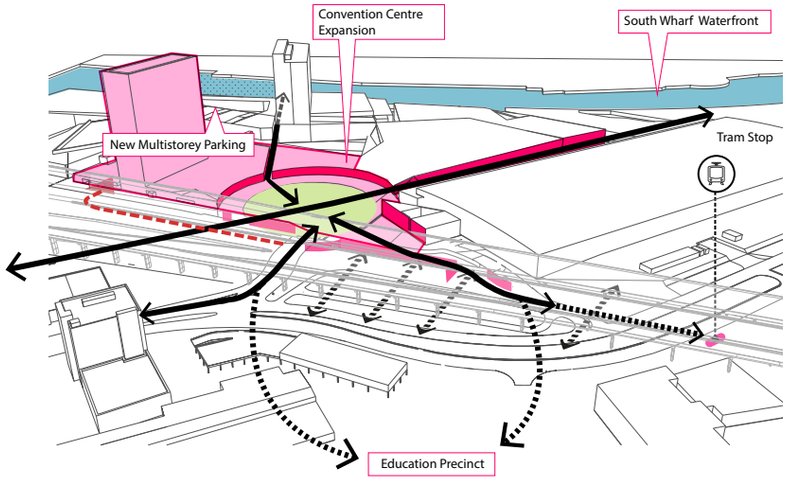
1. Context

At present each of the area's assets, attractions and focal area's for investment are dissected.

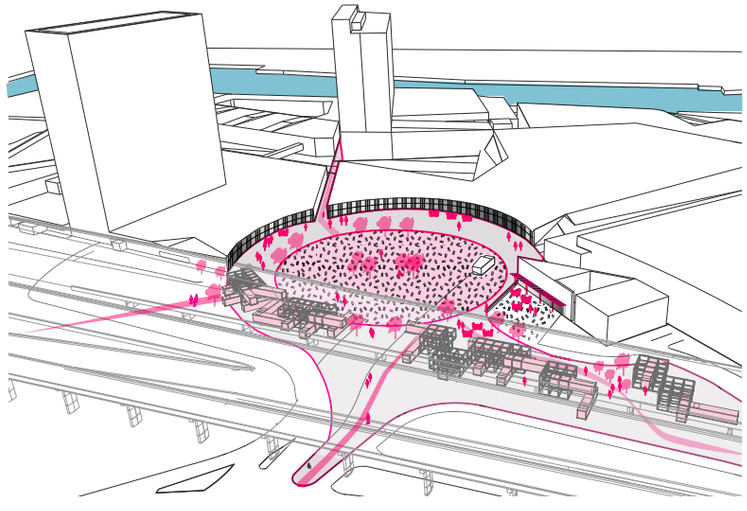
2. Integration

The strategy looks to join each of these assets via attractive pedestrian routes, focusing on the redevelopment potential offered by the undercroft spaces and car park. A new fulcrum space is established.

3/



4/



3. Infill

Infill development opportunities are identified, together with opportunities for landscape enhancement along the main pedestrian corridors.

4. Activation

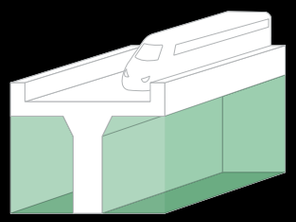
Use activation is orientated towards the new plaza with active frontage projecting onto pedestrian routes wherever possible. The quality of the pedestrian experience is greatly improved, overcoming the freeway's severing effect.

Addis Ababa LRT

Crossing the line in Africa's first metro system

ADDIS ABABA

ELEVATED RAIL



Overview

Addis Ababa has one of the most rapidly urbanising populations in the world and until recently has had a largely inadequate, even absent, public transport system providing only one seat across modes per 100 people. With Chinese investment, in 2015 a Light Rail Transit system was opened, which has substantially improved capacity, carrying 60,000 people per hour.

The Ethiopian Railway Corporation, supported by the Ethiopian Government, has prioritised urban infrastructure investment as a leapfrog strategy for urban development and economic growth. Bolstered by a strong economic environment and stable political climate, more than 35km of light rail transit (LRT) has been completed in the city. According to its initiators, the system will change the lives of residents of Addis Ababa and catapult the city into its envisioned role as the diplomatic and economic hub of the region.

The metropolitan LRT is part of an ambitious program that will see rail playing a major role in connecting the country and its east African neighbours with a complete network incorporating both light and traditional rail of more than 5000 km of rail envisioned across Ethiopia and into neighbouring ports and gateways.

Increased connectivity and more dignified transport does, however, come at a price, with large swathes of Addis Ababa's intimate urban fabric being uprooted and demolished to make way for the rail infrastructure. The rail line cuts across neighbourhoods and divides communities through a physical barrier that punctuates the urban environment with tunnels, viaducts, bridge stations, and at grade barriers that split busy thoroughfares into single direction trafficked channels that are difficult for pedestrians to navigate.

Images above taken from a Transit Orientated Development Study undertaken by Arup for Ethiopian Railways Corporation, ©Arup

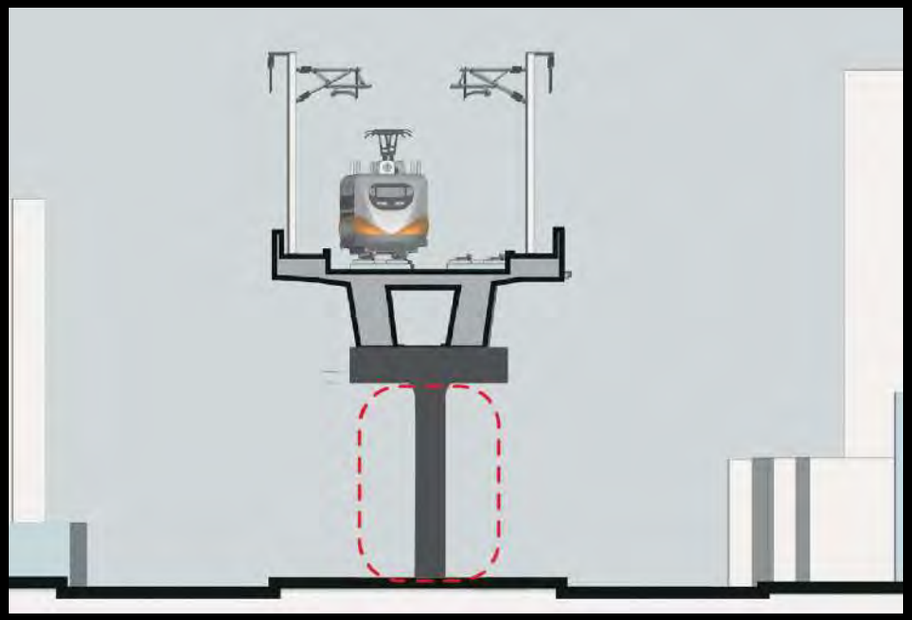
In a city where the primary mode of transport is walking, and where street trade is the norm rather than the exception, rail infrastructure has brought new challenges. Some attempts are being made to address these challenges through transit oriented development and the promotion of investment in pedestrian infrastructure and designed streets. However, the gains from such projects currently in the planning stages are still a long way off.

This case study attempts to uncover the possibilities of retrofitting the existing rail viaduct network undercroft spaces to address and mitigate its barrier nature and achieve better integration with the city and its citizens. It is an investigation into the potential of using the vitality of city life as a bridge to overcome a physical barrier. It is hoped that this line of enquiry can also inform the planning and design of future rail construction phases.

38/ Aerial view of the Addis Ababa, © iStock
39/ The large undercroft space provides conversion opportunities for a variety of potential functions, © Arup
40/ When placed at surface level, rail tracks can have a major severing effect on pedestrian connectivity, © Nico Parco
41/ The LRT has proven to be hugely popular, ©Daniel Joubert, Arup
42/ Bole Road: New transport infrastructure is having a major impact on the city's traditional urban grain, © Daniel Joubert, Arup

38/

39/



Although a fantastic public transport asset, when complete the LRT network across Addis will create a 55km-long pedestrian barrier transecting the busiest parts of the city

40/

41/

42/

Opportunities

Most of the railway is on a viaduct structure raised approximately 20m above the ground and typically accommodated within a wide street median. Long stretches of undercroft space are configured approximately 20m in depth and 25m in height, providing a sizable, well-sheltered and shaded flexible space able to accommodate a wide variety of potential uses.

As indicated opposite, infill of the viaduct spaces could be designed to realise a combination of three opportunities: water harvesting and energy generation; public realm improvements; and employment / retail units. In certain locations, housing could be considered (for temporary accommodation, potentially transitioning to homes of a more permanent nature.

Concept

Incremental growth of an 'amenity corridor'

The design exercise focused on Lideta Station. This station lies adjacent to one of the largest markets in East Africa, with people visiting each day from across the region. Mixed temporary accommodation is introduced in the viaduct undercroft spaces that enables visitors to have a dignified place to meet, rest and safely store their goods instead of camping out in the street as many are currently forced to do.

Temporary housing could be provided alongside retail kiosks and storage units within a transformed public realm that seeks to establish a tree-lined 'boulevard' character to the street.

Benefits

This strategy could have wide-ranging benefits:

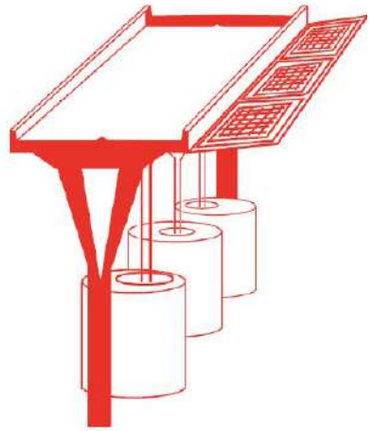
Environmental – Addis Ababa is a high land and water stressed city where making the best use of space through compaction and selective densification, even on a small scale, can have positive impacts.

Social – The use of these spaces can have a major positive impact on street vitality and integration through the introduction of new types of activity. In addition, the type of development proposed breaks down the scale of the rail infrastructure and creates a more human-scale interface between people and the transport network.

Economic – In Addis Ababa, economic activity is characterised by a high level of informality, which provides livelihoods for many without any level of formal support. Providing basic amenities within a range of low-cost spaces can be a way to recognise the role of informality and provide a level of dignity to traders and workers.

Securing energy and water

The launch of the LRT system in 2015, came at a time when the country was battling its worst drought in half a century, prompting fears of a repetition of the famine of the 1980's. Whilst the LRT system has an independent grid powered by hydro-elecric power, the growing scarcity of water in the city presents an opportunity to harness the extent of the LRT line as a productive channel for water harvesting and energy generation.

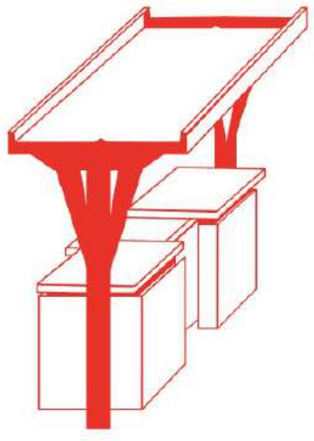


Trade in the shade

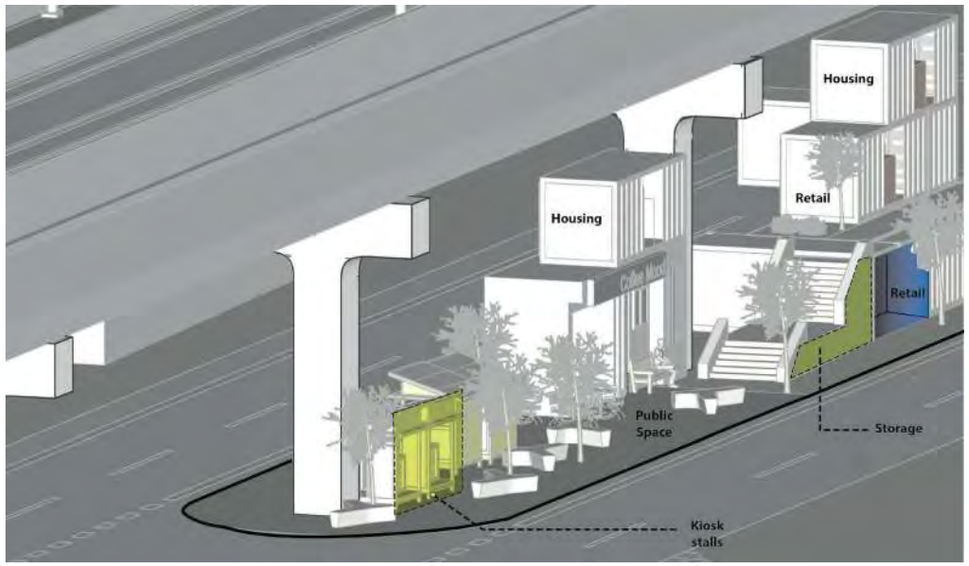
The viaduct undercroft spaces provide opportunities for low-cost retail and employment facilities to be provided. Potentially these could initially be introduced on a temporary basis, evolving and maturing over time.

Positive public realm

Addis Ababa's population of 4 million people has limited public open spaces, parks and congregation spaces to meet their recreational and social needs. Using the rail as the starting point of a city-wide green network could provide walking links for pedestrians to navigate the city in relative comfort and safety

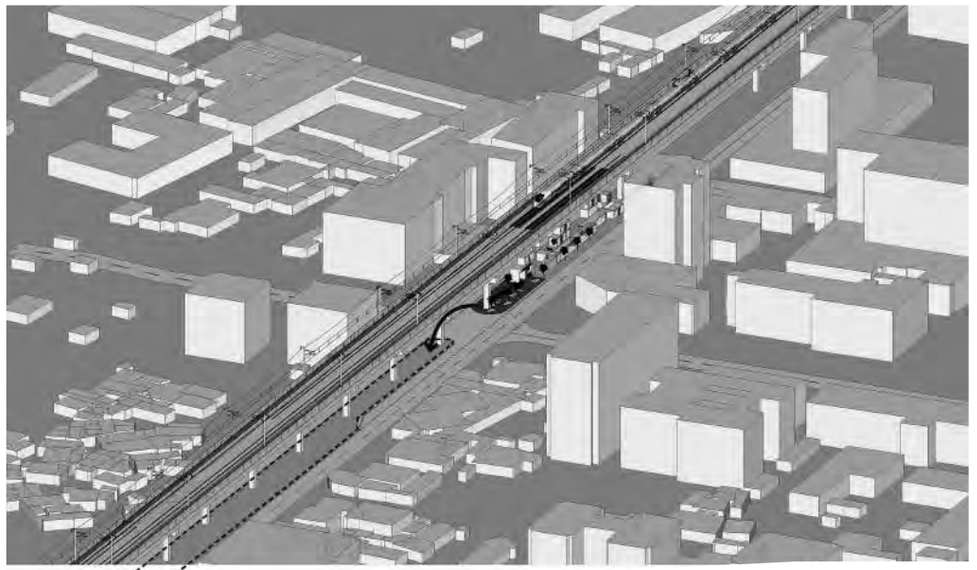


1/



2/

3/



1. *Undercroft space could be occupied using simple modular structures that can be developed incrementally to house a greater variety of programs/uses.*

2. *The development of undercroft spaces could be introduced incrementally – beginning in a trial area and extending over time. Initially, the spaces closest to stations could be prioritised for 'occupation and activation' to provide a range of essential public amenities*

3. *The occupation of undercroft spaces can also play a role in improving road safety in a city where pedestrian fatalities are high and walking is the primary mode of movement.*

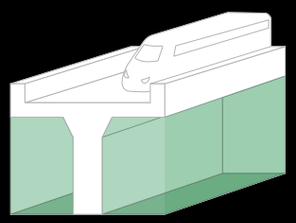
   Carefully designed occupation can help create clear areas for road crossing and channel pedestrian movement safely.

Sydney Skytrain

Integrated Sydney Metro Northwest and Hill Town Centre

SYDNEY

ELEVATED RAIL



Overview

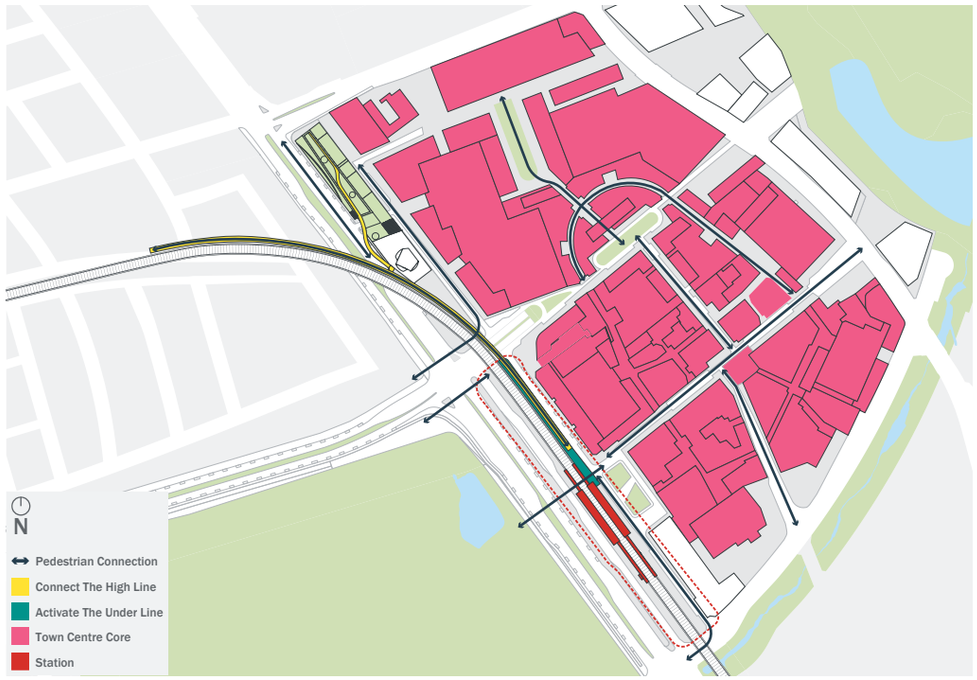
Rouse Hill is a suburb of north-west Sydney, located approximately 42 kilometres from Sydney's Central Business District. Rouse Hill Town Centre, which is privately owned and managed by the GPT Group, opened in 2007 to support the fast growing community. Accessibility to this part of Sydney is soon to be given a significant boost with the arrival of Sydney Metro Northwest, a rapid transit link, which is due to open in 2019. As the metro passes beyond central Sydney into the suburbs (between Bella Vista Station to Rouse Hill Stations) it raises onto an embankment or on a viaduct structure, the latter of which is referred to as the 'skytrain'.

The viaduct passes alongside the western edge of the Town Centre, with the station raised about 12 metres above ground creating a large undercroft space and substantial area of land at ground level that serves as the focus for our design exploration.

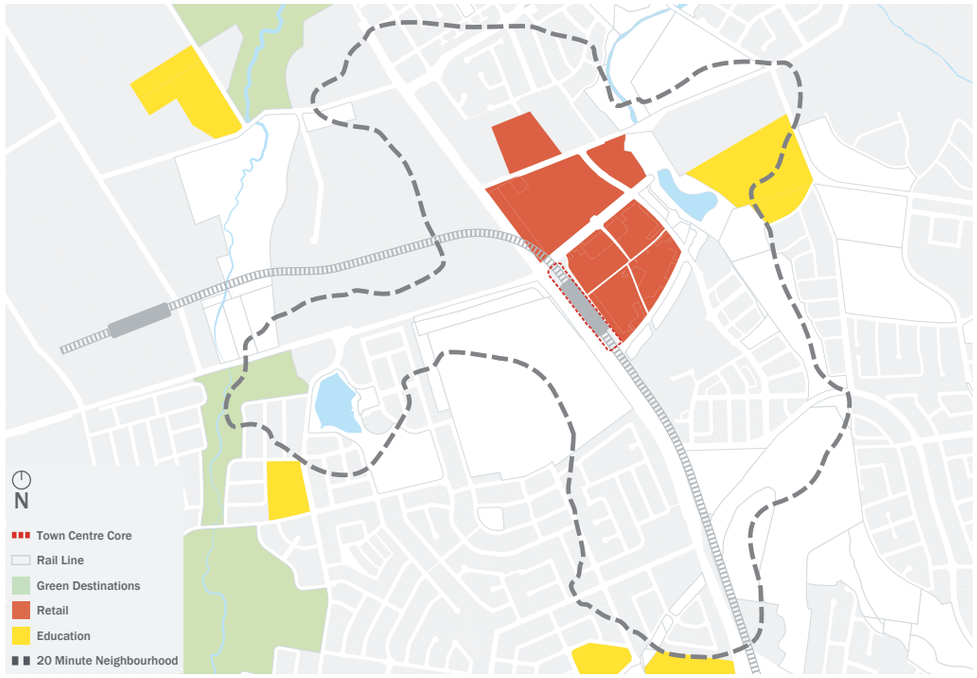
Opportunities

The opportunity exists to grow and re-orientate the town centre to take full advantage of the new station being built alongside it. This involves modification of the existing building edges initially conceived as 'backs' but which now face onto the new station, establishing a much more pedestrian-friendly public realm and activating spaces underneath the viaduct to capitalise on the commercial benefits of the increased footfall generated by the station whilst helping to reinforce this as the community hub.

1/



2/

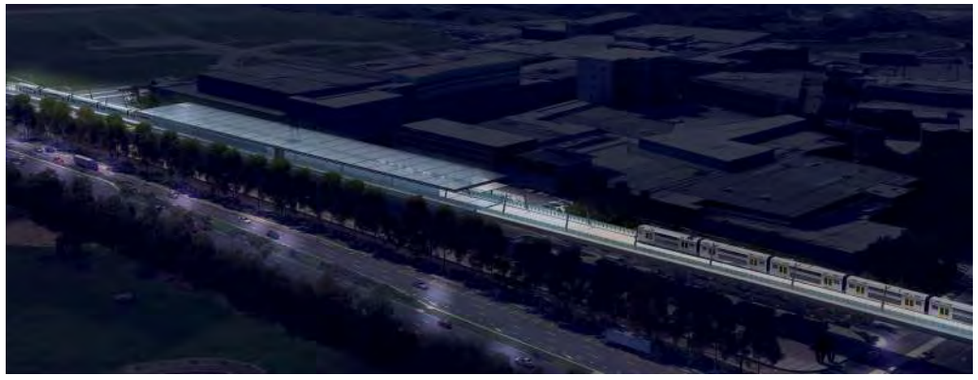


Concept

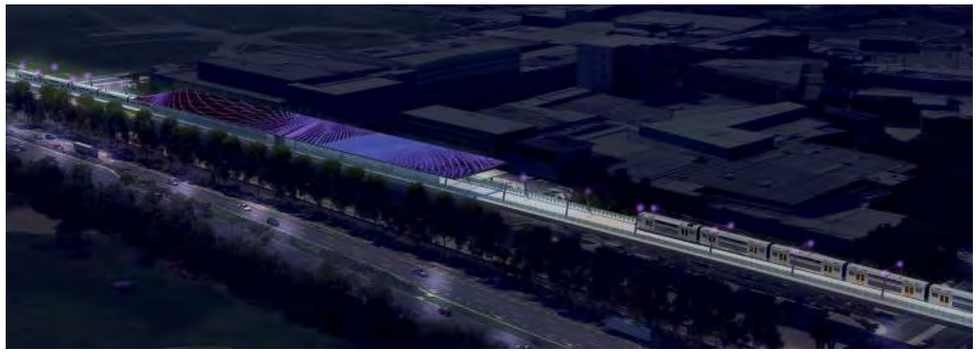
Implementation could be conceived in a staged manner. In the short term, temporary 'pop-up' activations could be introduced to grow, mature and adapt over time to become increasingly permanent in nature. Pedestrian and cycle accessibility would be maximised with the introduction of the bridge and the Town Square reinforcing the new town's identity – creating a lively space capable of programming for different activities (such as markets or festivals).

Lighting concept

Lighting has an important role to play in functional accessibility terms, and related safety and security considerations. Additionally, illumination of the viaduct could be considered to help shape the identity of this new community and provide a sense of celebration and creative expression that could, for example, tie in with Sydney's internally renowned festival of light, Vivid (https://www.vividsydney.com/).



Normal evening mode (conceptual lighting design)



Event mode (conceptual lighting design)

Benefits

This strategy could have wide-ranging benefits:

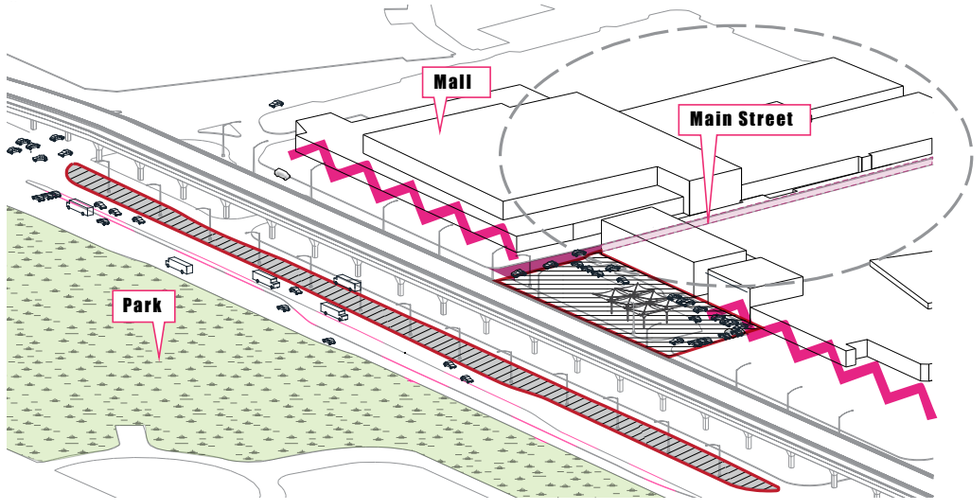
Environmental – reinforcing the station area as an active transport hub, with a pedestrian-orientated public realm transformation programme and enhanced footpath and cycle links.

Social – shaping a unique identity, providing opportunities for community-related uses to occupy spaces underneath the viaduct and contribute to the Town Centre's overall appeal.

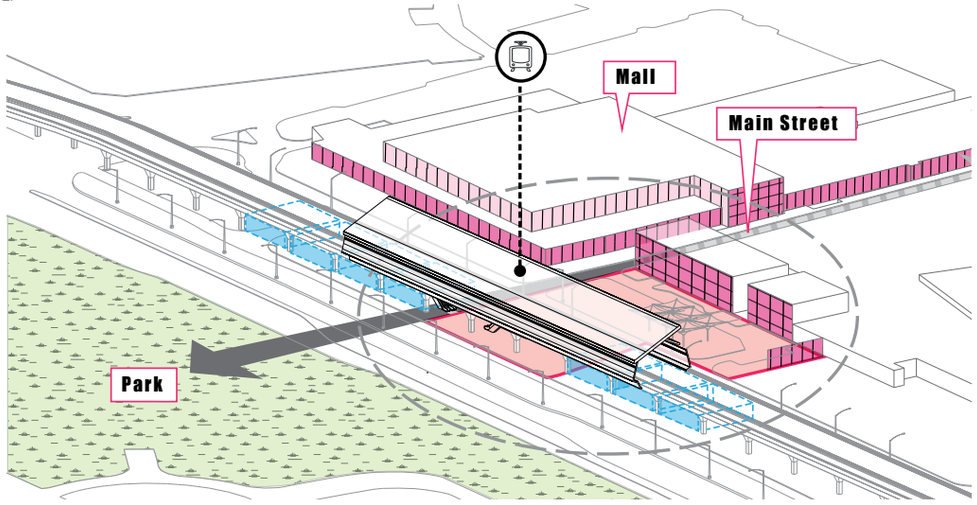
Economic – facilitating growth and invigorating town centre vitality and viability. Footfalls would be increased and the Town Centre would strengthen Rouse Hill as a destination – expanding its commercial and leisure catchment.

Sydney Metro Skytrain
Image courtesy of Sydney Metro Northwest, © Transport for New South Wales

1/



2/



1. Existing analysis

Internalised town centre

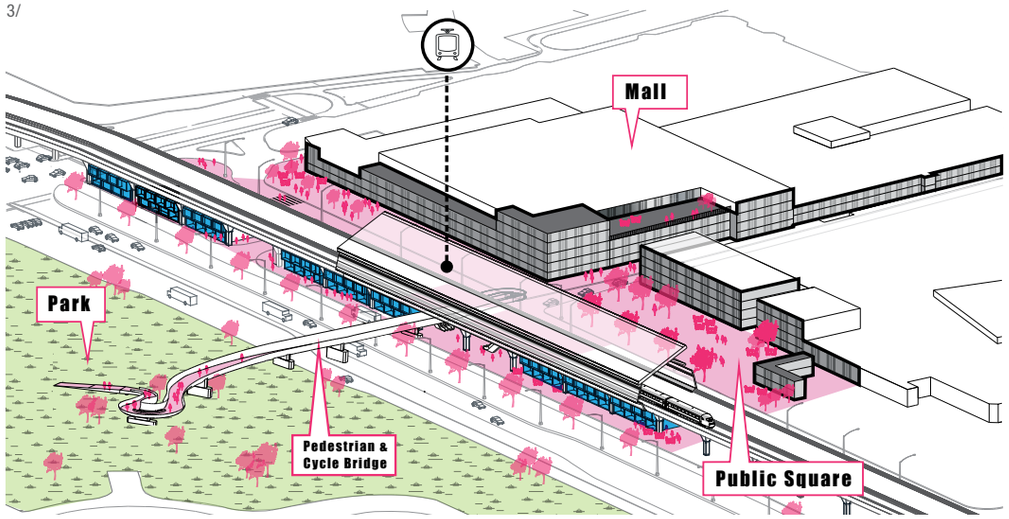
- *Unattractive exposed rear to 'big-box' retail*
- *Busy road and adjacent 'no man's land' severs the town centre from the park for pedestrians*

2. Opportunities

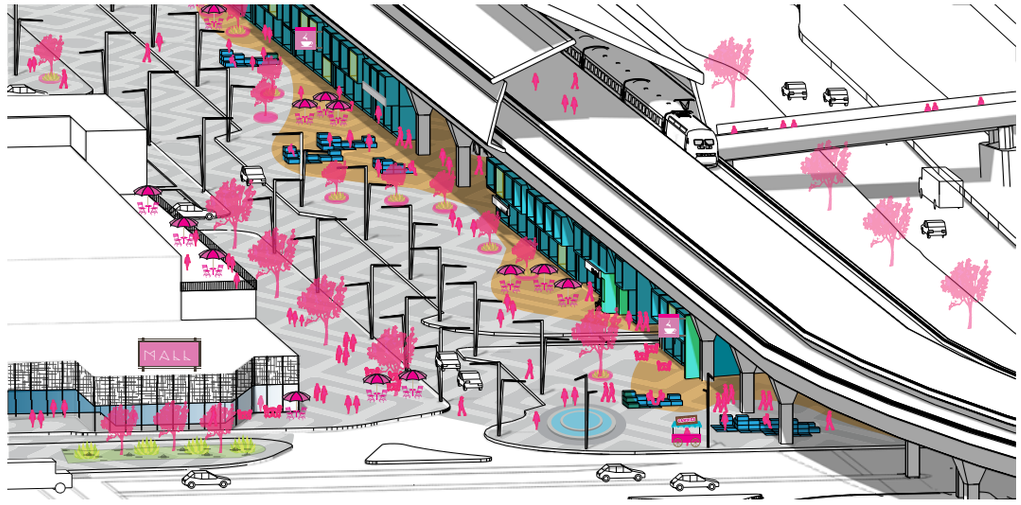
Pedestrian and cycle bridge connects Main Street and park via station

- *Transformed pedestrian Town Square*
- *Occupied viaduct spaces create activation*

3/



4/



3. Framework

Remodelled to orientate to street. A transformed Town Square, upgraded frontage to frame and animate square, and built-in viaduct undercroft spaces increase activation and vitality. Pedestrian and cycle bridge will enhance accessibility to the site and surrounds.

4. Activation

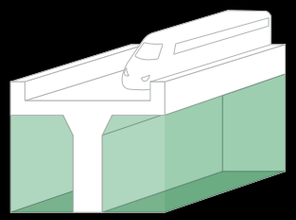
Viaduct activation helps animate a transformed Town Square.

New York Subway

"Under the Elevated" – Reclaiming space, connecting communities

NEW YORK

ELEVATED RAIL



Overview

The Design Trust for Public Space is a not-for-profit organisation concerned with unlocking the potential of New York City's shared spaces. In 2015, the organisation released the publication 'Under the Elevated: Reclaiming space, connecting communities,' prepared in partnership with the NYC Department of Transport. This summarises two years of research, design, policy and pilot implementation work focused on transforming the public spaces – or "el-space" – that lie beneath the city's 700 miles of elevated bridges, highways, subway and rail lines.

Most inspiringly, as a series of imaginative and engaging practical initiatives were piloted as part of the process in a spirit of "experimentation before implementation." These sought to "develop realistic, context-specific design and programming recommendations and test them." These ranged from modular green infrastructure systems and affordable studio space for artists.

The second phase of the program, entitled 'El-Space: Creating Dynamic Places Under the Elevated' has involved the launch of several pilot building projects. The first of these has been undertaken in Sunset Park, located beneath the Gowanus Expressway. This pilot aims to increase environmental health and enhance pedestrian safety for residents and workers at this busy intersection. Three Design Trust Fellows worked with students at Sunset Park High School and members of a Community Advisory Board to analyse the area and develop practical yet innovative solutions.

The Boogie Down Booth: One of the temporary installations that provided a sheltered, well-lit rest area that played music originating from the Bronx. As well as creating a playful space that promoted positive community interactions, the music served to help mitigate train noise.
Images courtesy of: The Design Trust for Public Space

Benefits

- The first phase developed design and policy recommendations, in partnership with the NYC Department of Transportation, to transform the neglected public space under the city's elevated transport infrastructure into valuable community assets.
- In addition, the first phase involved two pop-up experiments (Chinatown installation and Boogie Down Booth), which were undertaken with the input of a diverse group of New Yorkers, including Chinatown Partnership and the Women's Housing and Economic Development Corporation. These popular initiatives, co-designed with local people and conceived to celebrate local culture and identity, provided highly engaging, tangible demonstration projects.
- The partnership continues in a second phase to launch several pilots, the first of which being Sunset Park, cited as a collaboration with Industry City (https://industrycity.com/)
- This case study is a powerful example of a third sector – led initiative shining a light (quite literally!) on the potential use of space through the application of highly creative, temporary 'pop-up' installations.

Fellow Leni Schwendinger leading a NightSeeing™ tour, analysing the area after dark (www.nightseeing.net)
Image courtesy of: The Design Trust for Public Space

strategy

Turning creative imagination into practical realisation

findings

Reconceptualising the role of 'infrastructure'

It was Jane Jacobs in her seminal book the ***Death and Life of American Cities*** *who coined the term "border vacuums" in describing how large-scale transport infrastructure can have a severing effect on communities and cut off activity in public spaces. As she put it:*

"A border—the perimeter of a single massive or stretched-out use of territory—forms the edge of an area of 'ordinary' city. Often borders are thought of as passive objects, or matter-of-factly just as edges. However, a border exerts an active influence."

The active influence she referred to was the way that major elevated urban highways, for example, could create voids within the urban fabric and result in lifeless dead-end city streets at surface level. She decried the way that these major concrete barriers and their accompanying empty spaces created urban degradation within adjacent areas, blighting adjacent communities. Her treatise was borne of personal observation of the way that large, often elevated, highway infrastructure was slicing through well-established neighbourhoods within her much-loved New York and other American cities at the time of her writing in the 1950's. Some 57 years after its publication, these insights still hold true of many cities around the globe. Whilst there are examples of elevated infrastructure integrated into their urban context and designed in a way that enables ground level urban life flowing beneath, with active uses in their under-storeys, all too frequently these present disruptive barriers and empty space voids.

In formulating her views, Jacobs explicitly drew on the work of another leading urban theorist of the day, Kevin Lynch, who in his book the Image of City, reflected on the way linear infrastructure created community edges. He noted:

"An edge may be more than simply a dominant barrier, if some visual or motion penetration is allowed through it—if it is, as it were, structured to some depth with the regions on either side. It then becomes a seam rather than a barrier, a line of exchange along which two areas are sewn together."

This goes to the nub of our overall findings as to what makes successful elevated infrastructure. The decision to elevate rather than provide major transport connections at surface level will in many instances be necessary (particularly where tunneling is cost prohibitive), and the least disruptive option for existing urban life and properties However, *the starting point should be to explore the potential for these to be seen as seams rather than barriers, as the potential means to unite rather than separate.* In this regard the productive utilisation of viaduct under-spaces has a significant role to play. The undercrofts of railway viaducts, for example, can be designed to accommodate bars, restaurants and shops that animate the ground level street-scene, with criss-crossing pedestrian and cycle route-ways stitching the structure into its urban context. Indeed, sometimes this is so successfully handled that walking down such a street one can be forgiven for not realising there is an elevated rail track over-sailing above.

The philosophical approach

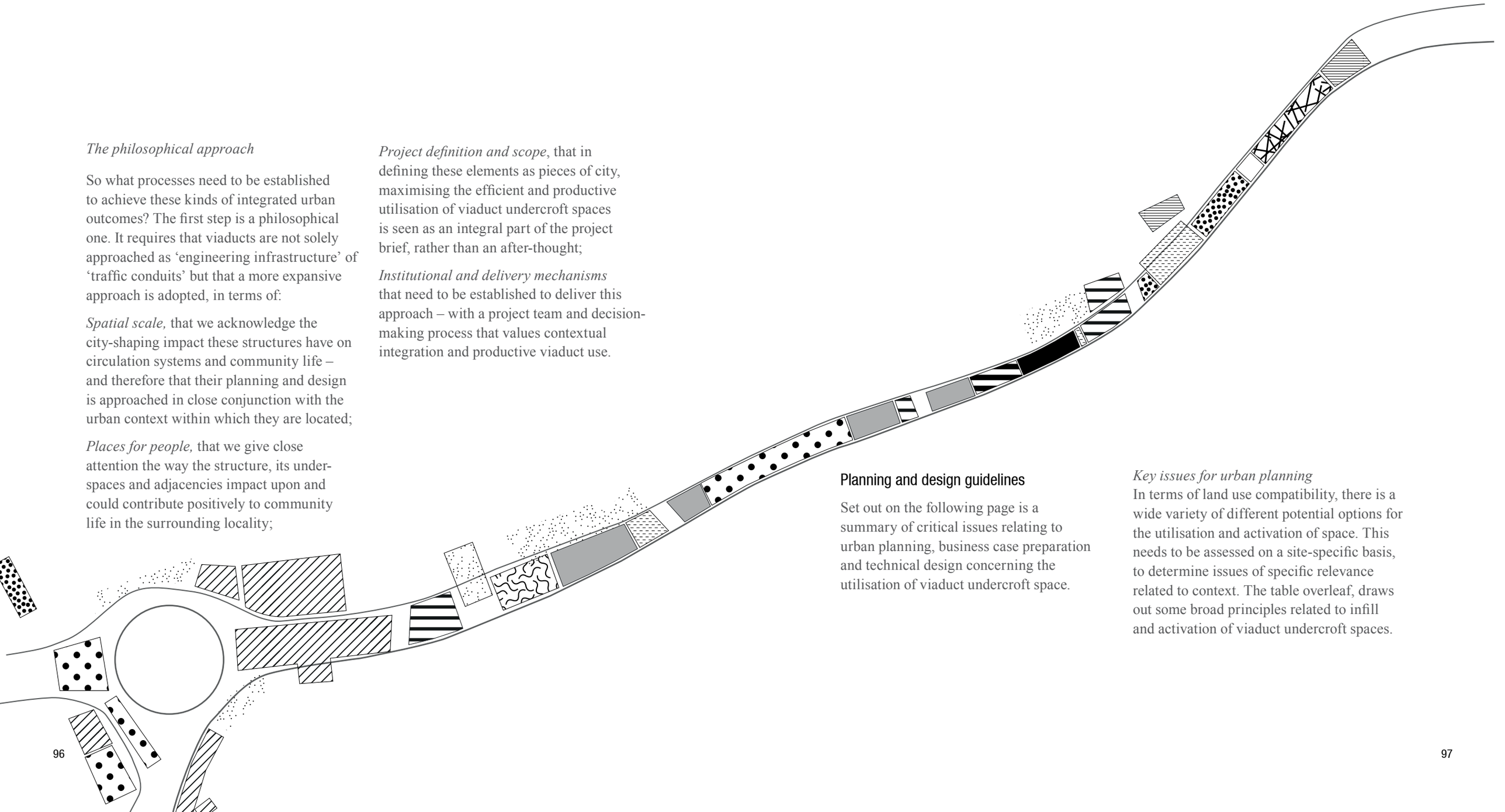
So what processes need to be established to achieve these kinds of integrated urban outcomes? The first step is a philosophical one. It requires that viaducts are not solely approached as 'engineering infrastructure' of 'traffic conduits' but that a more expansive approach is adopted, in terms of:

Spatial scale, that we acknowledge the city-shaping impact these structures have on circulation systems and community life – and therefore that their planning and design is approached in close conjunction with the urban context within which they are located;

Places for people, that we give close attention the way the structure, its under-spaces and adjacencies impact upon and could contribute positively to community life in the surrounding locality;

Project definition and scope, that in defining these elements as pieces of city, maximising the efficient and productive utilisation of viaduct undercroft spaces is seen as an integral part of the project brief, rather than an after-thought;

Institutional and delivery mechanisms that need to be established to deliver this approach – with a project team and decision-making process that values contextual integration and productive viaduct use.



Planning and design guidelines

Set out on the following page is a summary of critical issues relating to urban planning, business case preparation and technical design concerning the utilisation of viaduct undercroft space.

Key issues for urban planning

In terms of land use compatibility, there is a wide variety of different potential options for the utilisation and activation of space. This needs to be assessed on a site-specific basis, to determine issues of specific relevance related to context. The table overleaf, draws out some broad principles related to infill and activation of viaduct undercroft spaces.

Potential use compatibility of viaduct's undercrofts and issues for planning, urban design and acoustic engineering

Likely compatibility | Potential compatibility | Unlikely compatibility

	General Use Compatibility					
Potential Use	*Elevated Rail Undercroft*	*Elevated Highway Undercroft*	*Highway Junction Undercroft*	*Bridge Ramp Undercroft*	Planning and Urban Design	Acoustics
Shops					Examples abound of retail thriving under elevated viaducts in urban areas and close to stations. Elevated junctions (such as clover-leafs) are unlikely to support retail due to lack of pedestrian connectivity.	
Restaurants, bars and cafes					As above.	
Offices					In the right locations and where there is sufficient undercroft height and daylight, high quality offices can be accommodated. Elevated junctions (such as clover-leafs) are unlikely to support a high quality office environment.	Sensitivity of office space and proposed usage will determine indoor assessment criteria.
Light industry					Workshops are amongst the most common use of undercroft spaces.	
Storage or distribution					As above.	
Cultural and arts institutions					Uses such as museums and galleries are often compatible. Depending on their nature, arts-related attractions and installations can be considered in relation to junction undercrofts.	Configuration may dictate types of institution (e.g. permanent art gallery vs temporary pop up). Noise ingress has the potential to impact upon ambient conditions within the gallery / museum. Approach implementation of any acoustic arts and culture institutions (e.g. concert halls, performance spaces) with caution. Potential for vibration impacts to any installations would need to be considered on a case by case basis. Impacts would likely be greater from rail than highways.
Sports and leisure					Undercrofts can lend themselves well to sports and leisure uses such as cinemas, music venues, night clubs, gymnasiums, indoor or outdoor sports and recreation facilities. A cautionary approach to sports uses under elevated highways should be applied due to potential pollution.	Recommended ambient noise levels for cinema viewing are generally very low. Either a compromise on conditions or significant engineering would likely be required. Configuration may dictate type of music venue (e.g. amplified rock vs unamplified classical). Potential vibration impacts on projection equipment (cinemas, night-clubs).
Hotels					In the right locations and where there is sufficient undercroft height and daylight, hotel accommodation can potentially be viable.	Noise ingress for all options is potentially an issue, particularly for sleep disturbance.
Residential					A cautionary approach to providing residential accommodation under elevated highways should be applied due to potential noise and pollution. In the right location, where there is sufficient headroom to provide high quality accommodation this may prove viable with appropriate mitigation measures.	Noise ingress for all options is potentially an issue, particularly for sleep disturbance.
Education and health institutions					A cautionary approach to providing health and wellbeing uses, such as creches or clinics, under elevated highways should be applied, particularly related to children, due to potential noise and pollution. However, rail-related structures may provide opportunities.	Potential for significant impacts on learning and healing due to both airborne and structure-borne noise ingress. Impacts on speech intelligibility and sleep disturbance. Potential issues with vibration impacts to scientific equipment.

The table below identifies important urban planning considerations.

Key planning considerations

Urban context	Prepare a thorough contextual appraisal. What is considered appropriate for the utilisation of undercroft space will vary markedly according to the urban, suburban or rural setting.
Sustainability as a driver	Use available tools to maximise sustainability benefits, which can be a useful driver for a broader-based approach to viaduct planning and design. In Australia, for example, projects are often required to attain Infrastructure Sustainability Council of Australia (ISCA) rating standards. Such standards require whole of life costings to be adopted – forcing a focus on the operational phase (maintenance budgets) to be considered from the outset and encouraging support for active transport considerations.
Community impact and liveability benefits	Carefully consider the community impact of proposed viaducts, with measures integrated that result in enhanced liveability benefits wherever possible. Viaduct spaces can be well suited for sports and recreation facilities in pursuit of health and wellbeing agendas, for example. Consider, the potential displacement of existing informal users of viaduct spaces in relation to retrofitting projects (such as homeless people). In certain circumstances there may be opportunities to formalise existing occupation, such as affordable housing.
Property ownership and value	Understand the nuances of land and structure ownership as sometimes there are different owners. Often maintenance access rights are key. Define land ownership corridors at the initial project definition stage. Viability considerations related to land value and project costs need to be considered iteratively with planning and design solutions. Address viability in an iterative way with planning and design solutions, taking account of land value and project costs. Context is key to this; development under road flyovers / rail viaducts is common in inner urban city contexts where space is at a premium and the cost of land is high, and less common out of city areas where land values are lower and the focus on use efficiency is less intense. Consider potential community ownership models, which as Westway shows, can be applied order to maximise public benefit, local relevance and citizen involvement.
Connectivity and accessibility	Design-in pedestrian and / or cycle networks – both along linear corridors and laterally flowing underneath the structure, where possible Create 'walking loops' into the wider network, sometimes achieved by 'bolting-on' elevated pedestrian/cycle bridges onto existing road/rail bridge structures
Green infrastructure	Strengthen green infrastructure networks to create a 'city ecosystem' that joins up parks and open spaces; urban trees, streets, squares; woodland and waterways. (see https://www.arup.com/perspectives/themes/cities/cities-alive-rethinking-green-infrastructure)
Masterplanning	Assemble a multi-disciplinary team with all the technical skills needed to address environmental, social and economic considerations as part of an integrated approach to 'masterplanning and design development'
Access to light and overshadowing	Take account of the impact of elevated structures on adjacent properties in relation to direct sunlight and overshadowing
Land contamination	Assess the need for any necessary land contamination mitigation where viaducts pass through industrial / former industrial land and consider how viaduct transformation could contribute to a land rehabilitation strategy

Where the cost and/or technical ground conditions prohibit an underground solution to major infrastructure, taking each of these factors into account, elevated structures can often have a reduced community impact than, say, putting new rail lines or an urban expressway into a 'trench' that creates a divisive and unsightly barrier.

Key issues for business case preparation

The utilisation of viaduct space should be a key consideration in the preparation of the business case for the viaduct as a whole, followed by a more detailed business case prepared to frame individual viaduct activation components. Occupation or activation will tend to be more appealing to the entity who has long term property interest related to the land under the viaduct (which may differ from the structure owner). Benefit evaluation should take account of the potential for undercroft use to help deliver commercial as well as community value, potentially driving value uplift of the area with environmental enhancements or the creation of a destination.

Engineering design considerations

In relation to new-build viaduct infrastructure, the potential for the viaduct undercroft to be utilised for potential building floorspace should form an integral part of the design process. Key considerations for engineering design are summarised below (learning from best practice retrofitting projects such as the Sydney Harbour Bridge Bays and Westbourne Studios in London).

See table opposite.

Loading implications	Factor loading implications arising from undercroft use into building structure and foundation design at the outset.
Soffit as ceiling	Consider the potential for the bridge soffit to form an exposed ceiling for occupancy below, requiring close coordination between technical specialist inputs. The viaduct soffit could be provided with fixing points (and reasonable loading allowance added into the design) for connecting the bridge maintenance access walkways (if required) and to support reticulated services and ceilings for any developments below. In addition: • Fire insulation/fire separation is likely to be important. Providing capacity to support for fire insulation suspended from the bridge would be useful. • Structure-borne noise intrusion and internal room acoustics will be key to the function of each proposed usage. Appropriate space planning will be required in areas where exposed soffits are proposed as ceiling. • Designing/detailing the bridge deck to avoid water seepage to the soffit would be important. Providing capacity to support a waterproof deck or similar waterproofing system suspended from the bridge would be useful (where not addressed in the bridge design).
Column placement	Consider column placement in relation to the potential use and compartmentalisation of undercroft space. Due to the infrastructure development / planning process it may be highly challenging to integrate / coordinate with surface developments for which the detailed design may occur much later on. Columns for viaduct type bridges will generally be at fixed spans/ fixed centres under the headstock for repetition or economy. However, where there is potential for viaduct activation, adjustments can be made in relation to particular site or structural constraints.
Height and configuration of undercrofts	Where relevant, at the concept design stage, consider the potential merit (cost/benefit) of raising the viaduct structure height to help maximise the utilisation of infill space. Low heights can serve to rule out potential occupation or limit the types of facilities that could be incorporated (eg. some sports-related facilities that require large volume spaces) The clear height underneath can be increased by using shorter spans and through-structures. Minimum clear height to be usable for a building would be about 5m assuming access is required to the underside of the beams for inspection, or 2.5-3.0m if not. The higher the space, the greater flexibility there is for utilisation (though too high may prevent the soffit from being utilised as a ceiling). Lower heights suit a solution where the viaduct provides shelter or partial enclosure, whereas the higher viaducts provide a larger volume of 'air rights' but not necessarily shelter or enclosure. Old brick and stone arch viaducts had reasonable freedom in attaching fixings and services and often not require any lining/ceiling to the arches. With concrete structures these considerations should be considered as part of the design.
Aesthetics	The aesthetics of the viaduct structure is a consideration, though somewhat subjective. The 'Super T' cross-section is highly common, and can by some be considered unattractive. Where the space underneath is occupied, the structure can be designed with the intention to either conceal or expose the ceiling/soffit.

Other key issues for technical design

This section summarises some of the technical challenges relating to the physical design of viaducts as they relate to the utilisation of undercroft space, together with initial thoughts on design guidelines that address these. Several of these could also considered to be planning considerations.

Noise and vibration	Consider the implications of different noise and vibration characteristics of road and rail viaducts on use compatibility and design.	
Air quality	Consider implications of car exhaust pollution on appropriate highway viaduct use, including potential mitigating measures (such as physical barriers that could have a limiting effect).	Tends not to be an issue for rail projects.
Safety and security	Where possible, review the effect of regulations relating to viaduct uses, to ensure that they help facilitate, rather than overly constrain, positive utilisation, particularly relating to: – life safety and accessibility; and – security (such as hostile vehicle mitigation)	
Management and Maintenance	Facilitated accessibility requirements for inspections of the viaduct structure. Integrated maintenance costs and potential savings arising from viaduct utilisation into project business cases and feasibility analysis. Establish management plans. Engage local authorities early, which is key to achieving a maintenance agreement.	
Lighting	Where possible, explore opportunities to facilitate sunlight penetration into undercroft space (for example within central medians) and maximise ambient daylighting to promote landscape planting and appealing public spaces (including walkways and cycleways). Consider the role of lighting helping create vibrant, prosperous, safe and inclusive places for those who live, work and play in and around viaduct spaces – at all hours. The Arup publication Cities Alive: Rethinking the Shades of Night provides further detailed advice and guidance: www.arup.com/publications/research/section/cities-alive-rethinking-the-shades-of-night	
Utility services	Consider the integration of utility services (eg. power, lighting, telecoms, drainage) in relation to undercroft space use – particularly in land constrained urban areas. There may be justification to incorporate additional services into the viaduct deck to help facilitate undercroft conversion at a later stage.	
Temporary utilisation	Consider the potential for temporary space activation, using ‘pop-up’ or meanwhile uses to experiment and demonstrate potential.	
Artistic involvement	If casting concrete in situ, consider opportunities for artistic involvement in concrete patterning.	

©iStock

“Spaces directly below the viaduct are generally shielded from airborne noise from above. This lends support to initiatives related to these undercroft spaces.”

Mitchell Allen
Senior Acoustic Consultant, Arup

Soundscape

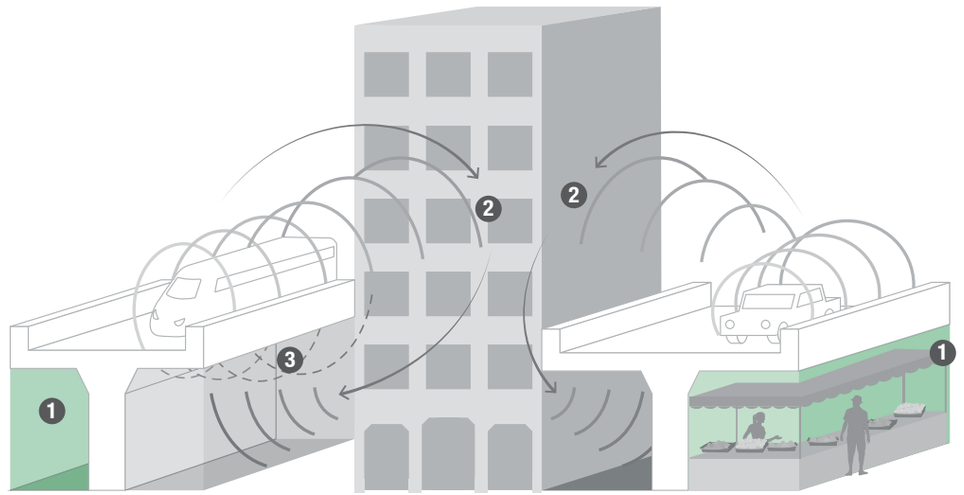
Acoustics are a key consideration for viaduct utilisation. The opposite illustration compares indicative noise transmission contours between road and rail viaducts.

A key difference between rail and road noise sources is the noise profile associated with each. Noise impacts from rail are generally intermittent whereas highways usually represent a more continuous noise source. This has the potential to influence both noise intrusion and noise emission from proposed developments beneath the viaduct.

As can be observed, in both instances the noise impacts of viaducts tend to be greater in relation to the areas adjacent to the structures than underneath the structures themselves. The areas underneath are somewhat acoustically shielded, lending support to initiatives that seek to maximise opportunities related to these undercroft spaces.

Structure-borne noise has the potential to be an issue for elevated rail and some elements of highway (such as expansion joints, rumble strip or pot hole). Depending on the proposed usage, it is generally possible to ameliorate these impacts through a combination of structural design, ceiling build and space planning.

For more noise sensitive uses, particularly those where sleep disturbance and speech intelligibility are critical, more significant mitigation measures may be required to be engineered. Depending on configuration, significant glazing build-up and provision of ventilation may be required to ameliorate airborne noise ingress and significant structural isolation may be needed to address structure-borne vibration.



1. Spaces directly below the viaduct are shielded from airborne noise.
2. Reflected sound from adjacent structures has potential to increase noise build up underneath viaduct.
3. Potential structure-borne noise.

Rail viaduct

- Intermittent noise source.
- Potential for structure-borne noise via wheel-rail interface.

Road viaduct

- More continuous noise profile than rail.
- Potential structure-borne noise from expansion joints, rumble strips, pot holes, etc.
- Entry and exit ramps potentially introduce noise source at lower level.

Key acoustic considerations are summarised below.

Higher intensity uses	Noise intrusion at surrounding receivers is typically assessed with respect to the existing background noise level. Given that the environment around elevated structures often has the potential to exhibit high ambient noise levels, this could serve to reduce noise emission restrictions on proposed use of the undercroft spaces. It is anticipated that highways are more likely to present this opportunity as they can exhibit more steady state and continuous noise in comparison to railway noise emissions which are intermittent.
Viaduct design	Rail viaducts where resilient or floating slab track has been installed will have significantly reduced structure-borne noise and vibration impacts below the viaduct. This may allow for more sensitive uses to be proposed, with reduced implications for the building structures design. Where solid parapets are constructed on the viaduct, air-borne noise to below the viaduct will be attenuated, increasing the opportunity for acceptable environments for outdoor uses, or reducing design implications of any built-form. In higher noise environments, more active outdoor uses may be acceptable, or built form could be used to attenuate noise levels for appropriate internal activities.
Built form	Space planning within any proposed buildings below the viaduct structures opens up the possibility for a wide range of uses from more to less noise sensitive. For example, depending on the configuration, it may be relevant to have a rooftop terrace that makes a feature of the viaduct, with more sensitive uses beneath. Appropriate acoustic criteria selection is key to promoting the flexibility of each space. There are many uses and types of development that are suited to a relaxation in standard noise criteria. This should be explored with potential stakeholders. Maintaining separation between any proposed structure via an air-gap or resilient layer (e.g. elastomeric bearing or springs) may ameliorate structure-borne noise and vibration impacts from the viaduct.

Process guidelines

Building on observations made from reflections on existing and hypothetical projects, a series of defining features have emerged that relate to the process of conceiving and designing for spaces under viaducts.

Unpacking these process dimensions can provide practitioners, funders and policy makers with a snapshot of key activities required throughout the planning and design process – both in relation to designing new infrastructure with viaduct under-spaces, or retrofitting viaducts to exploit opportunities for more productive utilisation of space underneath.

1. Establish the vision for infrastructure in relation to delivering community benefits

Fundamentally, the opportunities for occupying space under viaducts emerge from a common and defined set of values and vision for infrastructure to work harder than just providing strategic road or rail transportation along a linear route. It requires a comprehensive look at opportunities to promote active uses with good street, footpath and cycleway connectivity within the areas that the viaduct passes through and for maximising the potential for community and economic benefits to be derived at local, corridor and city scales.

Through the design process, this means that opportunities for undercroft space occupation are considered from the outset of project scoping and concept design, with these benefits defined, quantified and valued.

Guidelines or reference documents that pull together global exemplars for activation of viaduct spaces can provide decision makers with the inspiration to think creatively and consider different imaginative possibilities.

2. Design in features that promote flexibility in the use of viaduct spaces

The value of thinking early about these opportunities is to build in design features that support flexibility in space utilisation and occupation – for example the acoustics to support artist studios or office space, column spacing to enable larger-format spaces such as sports facilities to be incorporated underneath viaducts or the lighting conditions to support play spaces. Even if the conditions aren't in place to make these propositions successful in the short-term, measures can be integrated to help facilitate retrofitting at a later stage.

3. Design with the community, tapping into local knowledge and responding to local need

Early thinking in the planning and design process of the way that viaducts can make positive contributions to city neighbourhoods enables constructive conversations with the community to be opened up about the potential of undercroft space. Working with community groups taps into local knowledge, helps to understand the place and identify what spaces could be used for, as well as who could be involved in delivery and ongoing maintenance of space in the long term. It is important to gather a diversity of users for this process to explore widely the potential of spaces. In Australia, engaging local Indigenous community groups provides an opportunity to deeply understand the land, and provide a foundation for understanding the potential interpretation, conservation and protection of spaces.

Key questions that may guide this process include: How do places currently work? How do they flourish? What is lacking in the community? What could be enhanced?

4. Demonstrate public value early through the business case process and potentially through early activation projects

Citizens are increasingly demanding more from infrastructure – and decision makers are increasingly pressured to deliver more than a connection for rail or cars. In challenging environments, there is a need to work harder to demonstrate the benefits of change, throughout the design process. Installing interventions early can have a role in activation of space and provide an opportunity to showcase the future potential of a project. Temporary 'meanwhile' or 'pop-up' activations can also help to showcase the benefits of new infrastructure and engage communities to have an active role in transforming spaces. These can also be cost-effective experiments to test and learn from, and often evolve into more permanent features.

5. Identify the ecosystem to support activation and occupation of space

Designing for potential occupation or installation in undercroft spaces fundamentally needs to be 'of the place.' This means deeply understanding the ecosystem of likely actors and contributors to the design, activation, occupation and ongoing management of the space. These will span the breadth of the design process:

- Who are your allies that will champion the design process? Understand these and recognise they may change through the design process.
- What are the approvals processes? Who are the actors that understand and can influence the approvals processes?
- Who will benefit? How may we engage beneficiaries to be part of the design and ongoing management activities?
- How do the outcomes of this project align with other organisations? How might we identify other actors (for example local councils) to be art of the design process and be part of the ongoing management activities?

6. Develop a set of clear, measureable and ambitious goals

Establishing a set of clear and measurable yet ambitious goals, and monitoring implementation of an intervention, is key to tracking if the benefits anticipated in the design process are being realised and to ensure action can be taken if adverse outcomes are identified.

This monitoring requires that appropriate baseline data are set and that an evidence base for future interventions and investments is established, to provide a basis to determine what works and what doesn't, and providing lessons learnt to inform future designs.

7. Monitor the success of viaduct space utilisation against the performance metrics set

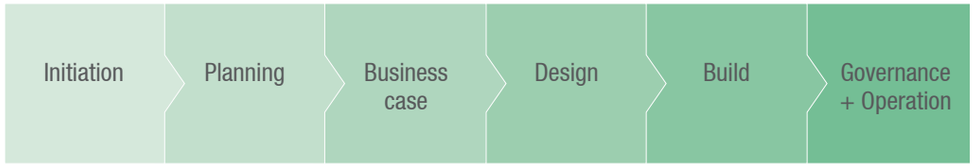
Monitoring information should be provided in a transparent way, with key metrics ideally shared publically.

We hope additional experience and research by practitioners, funders, and scholars will test and refine these concepts so that we can better understand and assess the impact of occupation and activation of spaces under the viaduct.

Issues to address through the project lifecycle

The table below summarises how the utilisation of undercroft space should form an integral part of each stage in the project lifecycle.

Viaduct optimisation considered at each stage of project cycle



Design

Who	Activites
Initiation Infrastructure agencies, metropolitan government agencies, potential developer, consultant team	• Adopt a strategic view to viaducts and their undercrofts • Identify broader benefits from occupation/installation – catalyst potential • Define client groups and needs • Consider viaduct utilisation in project scoping • Visioning to inform the project from the outset • Project seeding to establish demononstrator projects
Planning Infrastructure agencies, metropolitan government agencies, potential developer, consultant team	• Regard infrastructure as a catalyst for wider place-making impact • Undertake integrated masterplanning • Consider how viaduct utilisation can assist with risk management • Sustainability standards as driver (eg ISCA)
Business Case Infrastructure agencies, metropolitan government agencies, potential developer, consultant team	• Assess the benefits of viaduct utilisation comprehensively • Realise value by exploiting undercroft potential • Consider opex and capex funding requirements • Design or identify incentives to fund projects – who will benefit? How do we capture value?

Who	Activites
Strategic Design Potential developer transport agency, consultant team	• Develop clear, measurable and ambitious goals • Understand the place and community • Identify what is lacking and can be enhanced • Design-in flexibility • Consider undercroft use in optimising the structural solution • Environmental quality at every step of the way
Concept Design Potential developer / transport agency, consultant team	• Be unique – create ‘public rooms’ that reflect the character of the place • Involve the public – it’s their system • Identify the ecosystem to support activation/ occupation of space – who are people, processes? • Services and utilities
Build Contractor, community groups, local authority, consultant team	• Install with the community • Program with the community – consider the seasons • Include reference to undercroft use in the procurement plan and construction contract conditions
Governance + Operation Transport agency, local authority, community groups	• Test occupation/ installation against goals (track progress, review, reflect and refine) • Clarify space and structure ownership regimes • Define the governance model to encourage undercroft use • Involve the community • Address maintenance requirement

engage ment

Shifting the conversation on…

©iStock

recommendations for further research

Examples of viaduct activation from across the world convey the myriad of different ways that under-spaces can be designed and utilised to make a highly beneficial contribution to the communities within which they are located and to wider city-shaping objectives. The vast majority of these examples relate to retrofitting opportunities that were exploited long after the initial viaduct construction was completed. Our research has begun to highlight the potential and has explored in practical terms what can be done both in terms of process and physical design to help bring positive outcomes to fruition. However, it is only a start and further research is recommended. Here are some suggestions.

Strengthening the evidence base

Viaduct undercroft space utilisation is often an after-thought, and sometimes ignored altogether. This marginalisation is often the result of a project brief that focuses exclusively on the viaduct as linear transport infrastructure. Yet in certain locations the use of viaduct space can generate real economic and community value that can help project viability and potentially offer lasting revenue streams. This seems to be little understood. Further developing an understanding of what values can be created, using hard metrics, would be highly beneficial.

Business case preparation

Treating undercroft utilisation as integral rather than marginal needs to be embraced within business cases that are prepared at the pre-concept design stage. It would be useful to research how business cases can help make the case in ways that satisfy public sector project promoters whilst also encouraging the participation of developers and investors.

Regulations to facilitate rather than constrain

Regulations differ from place-to-place, but sometimes overly restrictive requirements can serve to rule out viaduct activation unjustifiably. With regard to successful case studies it would be useful to research in greater depth how technical requirements can be met whilst enabling the positive utilisation of space to be achieved (for example in relation to accessibility and life safety, or to maintenance inspection regimes).

Structural design for adaptability in new build viaduct design

The brick-built Nineteenth Century railway arches have proven to be immensely versatile. The elegant nature of the archways and the spatial configuration of void spaces continue to provide popular accommodation for workspaces shops, restaurants, cafes, restaurants, gyms and nightclubs – often converting between these uses over time in response to changing market demand and lifestyle preferences. This versatility is a product of the height and depth of spaces, their street address and a column spacing that facilitates compartmentalisation. What is the modern concrete equivalent? How can new viaducts be designed to facilitate this innate adaptability?

To plan or not to plan?

Paradoxically we need to plan and design for flexibility in both physical structures and governance arrangements, enabling ‘unplanned’ activities to occur over time and for the viaduct to be ‘absorbed’ into the city fabric. How do we get this balance right?

Community involvement

International examples demonstrate how successful undercroft activation occurs when bottom-up community involvement is allowed to flourish – with local ownership, spaces get colonised over time often in highly creative ways. What ownership, funding and governance structures can be put in place to encourage this?

About Arup University

Arup University, by investing in the development of our people and their skills, ensures Arup are known by clients, collaborators and competitors for our innovation, having the best design and technical expertise and a design culture. The cornerstones of Arup University are the facilitation of learning and knowledge sharing through Skills Networks, Research, Foresight and a Library team, all of which make a highly valuable contribution to the business and its future direction.

Thanks to all image contributors who provided photographic permission.

External contributors

Dean Boston – Transport for NSW
Hubert Dumont – UrbanGrowth NSW
Emily Mottram – Victorian Planning Authority
Anna Rose– LXRA
Noni Ruker – Ruker Urban Design
Michael Sheridan – RMS
Chris Stewart – LXRA
Graeme Thornes – The Westway Trust
Dr Ian Woodcock – RMIT University

Thank you to everyone who took part in the Arup workshops, events and forums and who provided insights on viaduct activation around the world.

Acknowledgments

Authors

Matt Lally
Safiah Moore

RMS lead

Gareth Collins

Arup contributors

Mitch Allen – Acoustics
Mike Cook – Building engineering
Daniel Joubert – Addis Ababa
Erin McCarthy – Urban design
Mark Rowland – Transport planning
Paula Saad – Urban design
Leni Schwendinger – Lighting
Alex Sinickas – Arup University
Dima Zogheib – Westway
Emily Dufner – Lighting

Illustrations

Joana Ferro
Pavla Brcakova
Annabel Shingler

Graphic design

Kathie Wallace
Annabel Shingler
Kim Visconti

About Arup

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. We offer a broad range of professional services that combine to make a real difference to our clients and the communities in which we work. We are truly global. With over 80 offices in 35 countries Arup has more than 13,000 planners, designers, engineers and consultants delivering innovative projects across the world with creativity and passion. Founded in 1946 with an enduring set of values, our unique trust ownership fosters a distinctive culture and an intellectual independence that encourages collaborative working. This is reflected in everything we do, allowing us to develop meaningful ideas, help shape agendas and deliver results that frequently surpass the expectations of our clients.

Shaping a
better world