

Corridors:

Designing linear

infrastructure in

a non-linear world

Research Report

September 2023

READING ROADMAP

01

READY Introducing corridors

'Corridors: Designing linear infrastructure in a non-linear world' takes a cross-sector look at the impact of built corridors on people and planet, as well as the impact of urban developments on natural corridors. Combining knowledge from the railway, roadway, waterway, and utility sectors across Australia, China, Singapore, Europe, and North America, we highlight the necessity for a unified, holistic corridor design approach.

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02

SET Corridors in evolution

In this chapter, we provide a concise overview of the evolution of corridors in conjunction with the establishment of early human settlements and their eventual role in modern civilisation. By synthesising the findings from an extensive literature review, we present the common challenges and opportunities that today's built corridors create and the drivers of change that prompt a more nature-positive re-evaluation of tomorrow's prospects.

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GO Taxonomy of corridors

By examining the typical users, uses, functions, shapes, and structures that define a corridor, the chapter introduces a common classification system to encourage comprehensive discussions across sectors and disciplines. This taxonomy also provides a basis for interrogating the fundamental purpose of a linear space acting in synergy with a wider, non-linear context.

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04

CIRCUIT Caring for corridors

Corridors are conventionally constructed and managed by highly specialised agencies that operate to achieve success within the confines of their sector and remit. In this chapter, we examine the priorities that set these agencies apart, as well as the shared objectives that unite them; namely, safety, sustainability, and community. We also discover how the potential for conflict can sometimes be greater within a single agency juggling multiple priorities than between different sectors and even regions.

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DESTINATION Corridors redefined

The concluding chapter summarises a new approach to corridor construction, design, and maintenance, which aims to bring together complimentary uses in better integrated systems, measured by holistic success criteria. To support this transition, we present a sector-agnostic toolkit to determine the wider potential of a corridor, its design attributes, and the outcomes it might produce. We finish with six projects from our own portfolio and ten projects from around the world, serving as practical sources of inspiration for catalysing change.

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SIDETRACK Learning about corridors

The appendix outlines our primary sources of learning. More than 50 stakeholders were engaged through roundtable discussions and interviews. Additionally, the study has been informed by a broad range of literature from academia and industry.

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READY

Hassell project render: Victoria Park-Canning Level Crossing Removal Project is Perth's first major level crossing removal project. Stretching 6.5 km, it is designed to improve public transport safety, reduce traffic congestion, and create new, vibrant public spaces for the community.



01



INTRODUCING CORRIDORS

LET'S TALK ABOUT LINEAR INFRASTRUCTURE

INTRODUCTION

From high streets to highways, rivers to rails, our planet is criss-crossed by linear pieces of infrastructure designed to facilitate the movement of matter across space.

Roads and railways carry people to work and leisure, power lines carry electricity to buildings, rivers return water from the hills to the oceans, and trails lead wildlife and seeds to new habitats.

According to the CIA's World Factbook, the global road network, railway network, and waterway network are an estimated 40 million km, 1.3 million km, and 631,000 km in length, respectively.¹ Combined, these corridors might take you one-thousand times around the Earth.

But linear infrastructure can also be a barrier to movement.

Roads and railways divide neighbours, power lines threaten bird migration, and rivers and trails become functional and administrative boundaries.

So far, in our pursuit to connect, we have fragmented the Earth's terrestrial surface into some 600,000 patches, of which more than half are smaller than a single square kilometre.²

By building connections across landscapes, we have segregated communities, ecologies, nutrient flows, and land use functions, inadvertently contributing to social inequality, biodiversity loss, and regional resource deficits.

For the sake of our planet and communities, we urgently need a new approach to tackle the multi-dimensional impacts of corridors.

Against the backdrop of a wide range of social (inequality, political conflict, cost of living), environmental (climate change, biodiversity loss, air quality), and economic (poverty, unemployment, energy crisis) issues, the shortcomings of a siloed approach to linear infrastructure projects are becoming increasingly clear.

We no longer have the resources, space, or ecological leeway to persist in constructing and managing linear assets focused solely on a single use. Nor can we ignore the wider non-linear context that inevitably exists alongside any linear space. Nevertheless, infrastructure agencies and projects continue to predominantly operate and secure funding guided by these principles.

We see the opportunities for unlocking new value by integrating functions and services, yet lack the tools to coordinate stakeholders and measure outcomes holistically.

We understand matters such as transport planning, land management, community development, and economic modelling, yet are without a common goal to align priorities across these (and other) areas of expertise.

All across the world, infrastructure agencies seeking to take a more comprehensive approach are coming up against the same problem: that their remit is fundamentally too narrow to address the wider impacts of their activities – and we are all losing out because of it.

In order to break the tunnel vision that dominates the linear infrastructure sector, we present a new perspective on the purpose and value of corridor design.

In this study, we uncover how linear infrastructure might be constructed, designed, and managed to deliver greater value for people, profit, and planet.

Chapter One defines the scope of the study, while Chapter Two outlines the context for change.

In Chapter Three, we propose a sector-agnostic taxonomy of corridors to encourage multidisciplinary discussions, and in Chapter Four, we offer an overview of the objectives that might unify different agencies toward a shared goal. In the final chapter, we combine these findings into a simple toolkit to help translate theory into meaningful action.

Our findings are based on an extensive literature review, conversations with industry stakeholders and colleagues, and an original analysis of infrastructure agency priorities. The study is geographically focused in Australia, China, Singapore, Northern Europe, and North America, where Hassell has practical experience in multiple fields of corridor design.

Through this report, our aim is to inform, inspire, and empower a worldwide transition to a more diverse, integrated, and outcome-focused method of shaping linear space.

For humans and nature alike, corridors are both the conduits for creating more resilient communities, increasing the prosperity of populations, and accelerating innovation – and the barriers leading to system fragility, stagnation, and decline.

The design, construction, and management of linear infrastructure is, therefore, a field of utmost importance.

1. CIA.gov (n.d.) Roadways compare the total length of the road network and includes the length of the paved and unpaved portions for 223 countries/regions. Railways compare the total route length of the railway network and of its component parts for 136 countries/regions. Waterways compare the total length of navigable rivers, canals, and other inland bodies of water for 118 countries/regions.
2. Ibis et al. (2016) The analysis applies a 1-km buffer to all roads.

SCOPE

In this study, we look at the impact of built corridors on people and planet, and the impact of built environments on natural corridors – and vice versa.

(We're leaving natural corridors in natural environments in nature's hands for now.)



1 Built corridors in natural environments

Interurban roads, regional canals, railways, and utility lines carrying water, power, and data.

Built corridors are constructed in natural environments for the purpose of connecting human settlements with one another and to regions of natural resource extraction.

Interurban roadways, railways, and canal interventions tend to catalyse significant positive economic outcomes, but may also disrupt natural ecological flows with serious environmental consequences.¹

For the health of nature, roads are generally considered to be the most problematic (especially for large mammals), while the impact of utility pipelines is less severe.²

Built corridors may be beneficial to local ecologies and biodiversity if verges are left unkempt and the presence of humans is relatively minor.³ Ecological bridges and viaducts can also help against the negative impacts of habitat fragmentation.

“If you put the road in the right place, it can become part of the landscape and local ecology.”

Stakeholder interview quote (anonymised)

1. Roberts et al. (2018)
 2. Wingard et al. (2014)
 3. Phillips et al. (2020)
 4. Badger & Cameron (2015)



2 Built corridors in built environments

Urban roads, urban canals, over and underground railways, and utility lines connecting buildings.

Built corridors in built environments usually exist to connect people to places of consumption, production, and resources.

In denser settlements, corridors can interlink and become more grid-like than linear. Strong linear corridors may also play a role in drawing boundaries between neighbourhoods, which can lead to segregation.⁴

The scale and speed of movement are key for the impact of the corridor on people and place.

Large, fast-moving corridors can have detrimental impacts on the local quality of life, yet bring important economic benefits at the region's macro scale. Conversely, small and slow-moving corridors can bring significant benefits to local populations but may be less effective in increasing a place's regional connectivity.⁵

“Corridors are about enabling more diverse land uses and sustainable densities.”

Stakeholder interview quote (anonymised)

5. Gonzalez & Lungu (2021); Quium (2019)
 6. Brown & Mijic (2019)
 7. Canal & River Trust (2023)



3 Natural corridors in built environments

Urban rivers and green corridors crossing human habitats, such as cities and towns.

Natural corridors are prevalent in most built environments, and once served as the very lifeblood that made human settlement possible.

With the advent of industrialisation, rivers became the centres of industrial activity while green belts gave way to factories and rapid urbanisation, altogether leading to widespread pollution and habitat destruction.

Today, the importance of natural corridors has been widely acknowledged for their ecological, aesthetic, and health benefits.⁶ Consequently, most cities with pre-industrial roots are working to restore and regenerate neglected ecological connections.

Additionally, green and blue routes may increasingly begin to play a part in the net zero transition of the urban logistics sector.⁷

“For a long time, the river has just been a post-industrial landscape. That's about to change.”

Stakeholder interview quote (anonymised)

DRAWING ON OUR OWN EXPERIENCE

The Colma Creek Connector project explores a range of options for restoring natural habitats and increasing community connectivity along a 3.2 km natural waterway.



Working across transport, urban design, and landscape architecture, we have experienced first-hand the opportunities that arise when sectors overlap and intersect.



With a planting scheme of 250,000 native plants, a natural habitat corridor is being re-established along Adelaide's Southern Expressway.



Hassell has been involved in the planning, design, and construction of more than 100 corridors world-wide, combining into 1,200+ linear kilometres.



Sydney's Metro North West project adds 36 km of railway line to the state capital's existing network, served by new and upgraded stations, and catalysing significant precinct developments.



RAILWAYS



MORETON BAY RAIL LINK
12.6 KM
Brisbane, Australia

Dual-track rail line between Petrie and Kippa Ring, including six stations. The project also involves road upgrades and a shared pedestrian and cycle path.



REGIONAL RAIL LINK
7.5 KM
Melbourne, Australia

Upgrade and extension works at four stations along the 7.5 kilometres brown-field rail environment between Footscray and Sunshine.



METRO NORTH WEST
36 KM
Sydney, Australia

The Sydney Metro Northwest train line comprises 36 kilometres of track – 23 kilometres of which are newly installed, with the remainder converted from heavy rail track for use by new single-deck, driverless trains.

“The best transport design delights the traveller, rewards the investor, and enhances the community.”

Peter Morley, Hassell Rail Sector Leader

ROADWAYS



PACIFIC HIGHWAY UPGRADE
26.5 KM
New South Wales, Australia

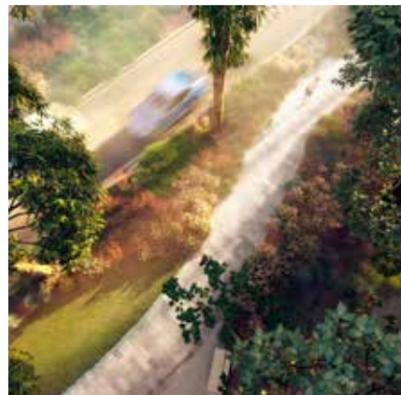
The Frederickton to Eungai upgrade project constructed approximately 26.5 kilometres of four lane divided highway on a new alignment to the west of the old Pacific Highway.

Image: Greg Jackson, © Transport for NSW



CROSS CITY TUNNEL
2.1 KM
Sydney, Australia

The Cross City Tunnel links Darling Harbour with Rushcutters Bay, creating new amenity for the city public domain, improving travel times and safety. It also enables motorists using the Eastern Distributor to directly access the airport.



WATERLOO ROAD
1.9 KM
Sydney, Australia

Hassell is working with the City of Ryde to transform Waterloo Road into an active street. With an additional 380 trees, we doubled the canopy coverage from 20% to 40%, meeting the Sydney Green Grid target.

“Designing corridors is not just about connecting A to B. We have to design a great experience between A and B too.”

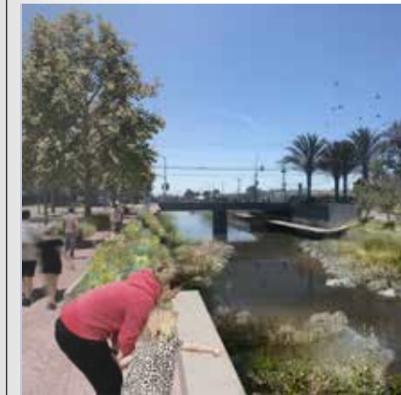
Angus Bruce, Hassell Head of Landscape Architecture

WATERWAYS



WEST BUND WATERFRONT
11.4 KM
Shanghai, China

A series of seven waterfront area upgrades spanning 11.4 km from north to south along the Huangpu River. Since opening the first of seven sections in 2021, the West Bund has become one of Shanghai's most loved destinations.



COLMA CREEK
3.2 KM
San Francisco, USA

Both a priority conservation area and a key link to the Bay Trail, the creek could be restored to bring back wildlife and create healthy, public open spaces for people to enjoy.



RIVER TORRENS LINEAR PARK
30 KM
Adelaide, Australia

Stretching from the Adelaide Hills to the west coast and winding through the city's suburbs and central heart, between 1979 and 1997 the River Torrens was transformed from an unsafe and unsightly drain into one of Adelaide's most-loved destinations.

“We have to understand our waterways as places that can bring ecological, social, and economic opportunity in equal measures.”

Chong Wang, Hassell Shanghai Managing Principal

GREENWAYS



SOUTHERN EXPRESSWAY LANDSCAPE
18.5 KM
Adelaide, Australia

The project focused on re-establishing a habitat corridor along the road alignment. The extensive planting scheme included 250,000 native plants.



TANSHAN TANGQUAN
3 KM
Nanjing, China

Built river and linear park corridor in new town development including public open space as social infrastructure for the new community.



VICTORIA PARK-CANNING LXP
6.5 KM
Perth, Australia

By removing level crossings for the railway line, the project sets out to return a previously inaccessible transport corridor to communities and nature. The new world-class 6 ha park has been designed to enhance the sense of place, improve ecologies, and rebuild connections to Country.

“Cities can and should be buzzing with people and pollinators. Connecting existing green spaces and waterways with infrastructure is key.”

Jon Hazelwood, Hassell Public Realm Sector Lead

SHAPING A NEW PARADIGM

THESIS

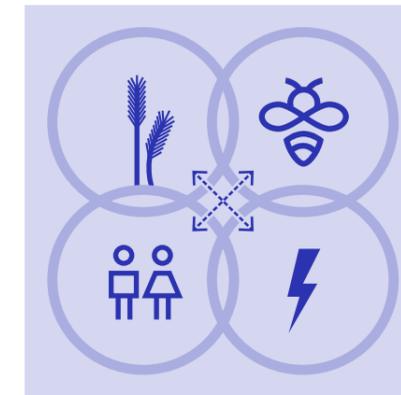
With this report, we set out a new, interdisciplinary approach to corridor design.

By showing that corridors always produce complex outcomes, we argue that they must also be designed and managed as complex networks – bringing together overlapping uses, integrated systems, and holistic measures beyond the linear space.

To support this shift, collaborative management structures, innovative design solutions, and shared decision-making tools will be essential.

From isolated uses...

to overlapping uses.



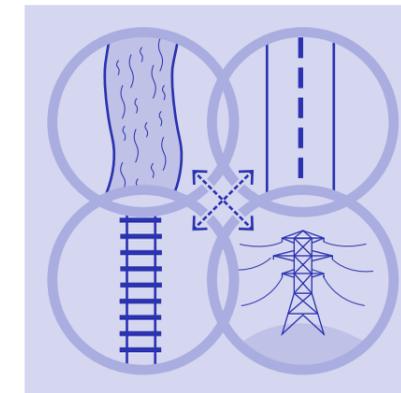
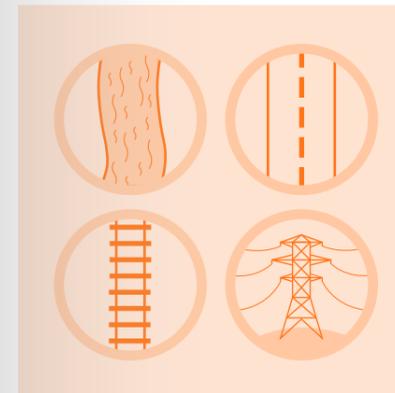
Healthy corridors are designed with multiple uses and users in mind.

Do: combine complimentary uses.

Don't: include everything and everyone just for the sake of it.

From siloed systems...

to integrated systems.



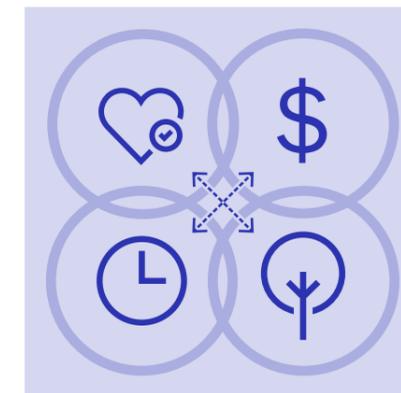
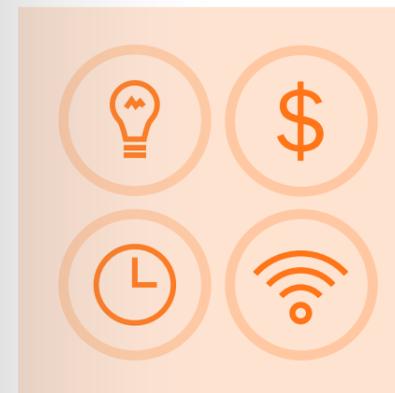
Healthy corridors are designed as integrated movement systems, driven by needs and not by sectors.

Do: develop new technology solutions to overcome silos.

Don't: invent new silos.

From simple metrics...

to holistic measures.



Healthy corridors are designed to perform against a holistic set of measures.

Do: set KPIs that reflect social, environmental, and economic needs.

Don't: forget to value that which cannot be measured.



SET

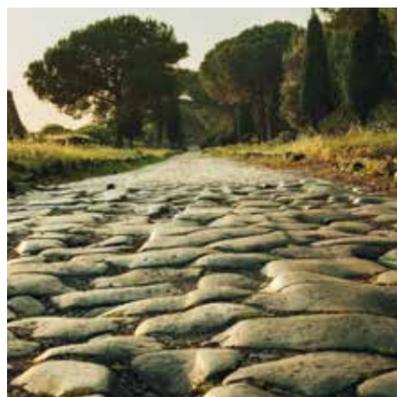
02

CORRIDORS IN EVOLUTION

Hassell project image: West Bund Waterfront
public realm design, Shanghai, China.

A BRIEF HISTORY OF CORRIDORS

FROM THEN



The planet has always been marked by linear features, both uniting and delineating different regions.

For hundreds of millions of years, geological corridors like canyons and valleys have helped move water, nutrients, and organisms through the landscape, shaping natural environments and transforming ecological communities. For almost as long, animals in search of food, shelter, and safety have drawn migratory paths in the natural terrain, dispersing seeds, microorganisms, and fertilisers in their wake.

For tens of thousands of years, humans were also using and creating such trails for their own movements, occasionally driven by cultural or spiritual customs.¹

About 6,000 years ago, humans settled on the European, African, and Asian continents added the first *built* corridors to our planet's collection of linear landscape features.

Paved streets, irrigation systems, and canals became the backbones of pre-industrial settlements.

The first paved streets and human-made irrigation canals were constructed in former Mesopotamia around 4,000 years BCE.² A few thousand years later, streets and canals crisscrossed parts of Europe, Africa, and Asia, from England in the west to China in the East, from the Northern African continent to continental Europe.

Started in the 5th century BCE, the Grand Canal in China was a waterway network of 2,000 km by the 13th century,³ while the ancient Romans had built an 80,000 km highway system all the way around the Mediterranean by the year 500.⁴

As Europeans colonised America (1565) and Australia (1788), built linear infrastructure also spread on these continents, often supplanting natural trails created and used by native peoples.⁵

With the industrial revolution, corridors quickly became wider, longer, faster, and more plentiful.

In the 19th century, advances in transportation and communication technologies created new corridor typologies, which in turn fuelled the industrialisation of towns and regions.

First came railways (1804), then telegraph (1838) and telephone (1881) transmission lines, subways (1863), electricity networks (1889), and eventually motorways (1924).

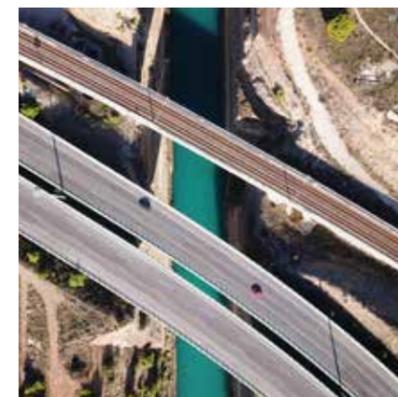
Many of these connections were planned and funded by private organisations with the purpose to facilitate goods movements and other economic activities and, as a result, the overall networks did not always come together seamlessly.⁶

Still, overall connectivity was increasing, bringing wealth and prosperity to communities all across the world. Though not everyone would benefit equally.

1. Crabtree et al. (2021)
2. Longfellow (2017)
3. UNESCO (n.d.)

4. Encyclopedia Britannica (2018)
5. Fuller (2016)
6. Australian Rail Track Corporation (n.d.) & Stakeholder Interviews (2022)

TO NOW



By the 20th century, the negative impacts of linear infrastructure networks started to show.

As the types, number, and scale of linear infrastructure corridors grew, the dangers and barrier effects also became more apparent.

Some issues (such as species extinctions caused by habitat fragmentation) arose inadvertently through sheer ignorance and inexperience, while other negative impacts, such as racial segregation and slum demolitions, were carefully and ruthlessly engineered (essentially weaponising corridors).

The U.S. Department of Transportation estimates that more than a million people, largely Black and poor, were displaced nationwide in the mid-20th century due to roadway construction by the federal administration.⁷

Also in the 1950s, a U.S. landmark study was one of the first to conclude that better, faster roads resulted in more animal highway kills.⁸

Yet throughout the 20th century, we've only continued to build more one-dimensional corridors.

Since the invention of the automobile, roads and highways have become the most common form of linear infrastructure for movement, while the use of canals and railways has declined.

In the US and UK, railway construction peaked around World War I,⁹ while in Australia, it stalled after World War II.¹⁰ Canals, once vital for goods transportation, were largely abandoned and have since deteriorated environmentally.¹¹

The world saw its first Ethernet cable in the 1970s, making data cabling the latest integral part of the world's network of utility corridors.

Responding to the demands of population growth and urbanisation, the 20th century also witnessed the emergence and consolidation of large, siloed corridor management agencies.

As our connectivity demands evolve, it's time to rethink what we need our corridors to be.

Estimates suggest that around 25 million km of roads and 335,000 km of rail track will need to be developed across the world between 2012 and 2050 to meet rising demands.¹²

In China alone, there are plans for expanding the high-speed railway network to 50,000 km by 2025.¹³ In Australia, new urban railway lines are being built across Melbourne, Sydney, Perth, and Brisbane. In the UK, the High Speed 2 project remains a key government priority. In the US, the Biden-Harris Administration has promised US\$110 billion in new funds for roads and bridges.

With every corridor project comes new opportunities and challenges. But it's only by understanding these spaces holistically that we might make them meet all of our needs.

7. Evans (2021)
8. McClure (1951)
9. Burns (2023) & Gunn (2018)
10. Australian Rail Track Corporation (n.d.)

11. Gibbons et al. (2019)
12. Dulac (2013)
13. Mang (2022)

Built linear infrastructure usually brings significant economic opportunities.

OUTCOMES

However, the social outcomes are often equally positive and negative, and environmental impacts tend to be mostly detrimental.

Meanwhile, investments in natural corridors tend to bring positive returns across all dimensions.

POSITIVE

ECONOMY

- Economic growth
- Economic development
- Economic resilience
- Land value increases
- Productivity gain
- Innovation gain
- Income gain
- Consumption increases
- Market accessibility
- Labour mobility

SOCIETY

- Social opportunity
- Social inclusion
- Wage growth
- Job creation/employment
- Community connectivity

ENVIRONMENT

- Aesthetic resource
- Biodiversity gain (wild verges)

“... the evidence suggests that investment in transport infrastructure tends to reduce prices and boost levels of investment, trade, and productivity, while also promoting industrial diversification and improvements in allocative efficiency.”

Roberts et al. (2018) meta-analysis of 234 estimated impacts of large transport infrastructure projects found in 78 studies.

NEGATIVE

ECONOMY

- Weather & climate-related disruption
- Financial burden (maintenance, liability)

SOCIETY

- Community segregation
- Physical isolation
- Social exclusion
- Spatial inequality
- Collisions and mortality

ENVIRONMENT

- Habitat fragmentation
- Genetic isolation
- Habitat destruction
- Deforestation
- Biodiversity loss
- Pollution (air, noise, water, light)
- Poaching & illegal harvesting
- Ecological degradation
- Wildlife collisions and mortality
- Disturbance to migration patterns

“The ubiquity of road networks and the growing body of evidence of the negative impacts that roads and other linear infrastructure have on wildlife and ecosystems suggest that infrastructure represents a major driving factor of biodiversity loss.”

Benítez-López et al. (2010) meta-analysis of 49 studies on 234 mammal and bird species.

NOTES The table outlines the typical positive and negative outcomes generated by constructed corridors, as per a wide range of academic studies. The outcomes are generally shared across the roadway, railway, and utilities sectors, with some variations in the scale and nature of impact. While we do not delve into the details and nuances of each outcome, the overview illustrates a notable disparity between economic and environmental benefits across the spectrum. It is these apparent imbalances that require our broad attention.

KEY SOURCES Agrawal et al. (2017); Benítez-López et al. (2010); Quium, 2019; Roberts et al. (2018); Wingard et al. (2014); Wu & Li (2022).

DRIVERS OF CHANGE

FIVE DRIVERS

ENVIRONMENT Weathering the coming storms

- Extreme weather events and natural disasters are becoming more frequent and more devastating, causing serious damage to built infrastructure assets. The World Bank has estimated that the direct damage to transport infrastructure from natural disasters costs about US\$15 billion annually.¹
- Rising temperatures and rising sea levels are displacing communities and increasing the pressure on our infrastructure systems. It is estimated that in England, 1,600 km of major roads, 650 km of railway line, and 93 stations are at 0.5% or greater risk of coastal flooding or erosion by the 2080s.²
- Global biodiversity loss is reducing the planet's ability to regulate greenhouse gas emissions, accelerating climate change and leading to further biodiversity loss. Linear infrastructure has been named one of the largest threats to biodiversity through the destruction and fragmentation of habitats.³ To counter this trend, Network Rail (UK) has committed to end net losses in biodiversity on its land by 2024 and achieve net gain by 2035.⁴

TECHNOLOGY Between innovation and disruption

- Mobility innovation is increasing the autonomy of different transport modes, potentially creating safer and more energy-efficient solutions, while also forcing us to rethink the use and capabilities of underlying infrastructure systems. The global micro-mobility market is expected to grow from US\$44 billion in 2020 to US\$215 billion by 2030.⁵
- Increasing computing powers and intelligent digital tools (AI, digital twins, augmented reality, internet of things, etc.) promise to increase the efficiency and safety of mobility systems through real-time demand management and remote repair works. In 2022, HS1 completed the UK's first 5G-enabled augmented reality digital twin trial, showing how this technology can reduce emissions and cut delays on UK railways.⁶
- New materials, fuel technology, and energy solutions are changing the limits of what can be achieved for the scale, scope, and sustainability of our linear infrastructure systems. The University of Cambridge is, for example, investigating the use of nanomaterials for pavements and oil-free asphalt for future roads.⁷

Corridors are increasingly under pressure to respond to changing environmental, technological, political, economic, and social realities. How can the corridors we build today prepare us for the challenges of tomorrow?

POLITICS Planning for an uncertain future

- Global climate commitments are driving stricter carbon regulations and new green governance legislation, impacting how large-scale infrastructure projects are awarded and assessed. The European Commission has, for example, put forward a strategy to double high-speed rail traffic in Europe by 2030.⁸
- Growing resource shortages, extreme weather events, and cyber-attacks are putting pressure on nations and companies to become more self-sufficient, requiring governments to rethink supply lines and places of production. In 2021, economic ministers from Australia, India, and Japan launched the joint Resilient Supply Chain Initiative to address supply chain resilience in the Indo-Pacific.⁹
- Strapped public budgets and the politicisation of transport and urban planning are creating an increasingly reactive public sector. This reality is adversely impacting the long-term planning and maintenance of critical national and international infrastructure systems. Infrastructure Australia estimates that inaction relating to the acquisition and protection of future corridors is costing the country billions of dollars.¹⁰

ECONOMY Redefining customer relationships

- Increasing construction and operating costs are putting pressure on infrastructure owners and managers to create leaner, more efficient systems. The UK's Network Rail is bracing for a record-breaking £1bn energy bill next financial year (2023/24), as costs increase 50% due to geopolitical unrest disrupting European supply chains. Some of these costs will be passed on to the users of rail.¹¹
- The digital economy is disrupting the dynamics of how people travel, and how transport services can be delivered and paid for. Fortune Business Insights projects that the 'mobility as a service' market will hit US\$775 billion by 2029.¹²
- Logistics networks have been heavily impacted by a rise in e-commerce and online shopping, accelerated by extended COVID-19 lockdown periods. In 2021, a report prepared for the New York City Council established that travel delays caused by delivery trucks occupying road and curb space cost New Yorkers US\$400 million annually.¹³ New legislation is now underway to designate specific 'loading-only' parking spots.

SOCIAL Meeting the needs of diverse communities

- Population growth and continued urbanisation is putting existing infrastructures under pressure, and raising the demand for new construction. A 2013 OECD/IEA report estimated a need for 25 million km of new roads and 335,000 km of new rail track by 2050, marking a combined 60% increase on 2010.¹⁴
- 1 in 6 people in the world will be aged 60 years or over by 2030 – a significant growth in both the size and proportion of older persons in the population.¹⁵ Transport systems will have to adapt to accommodate the needs of older people, who will demand more accessible infrastructure and connections to places of healthcare, family, and leisure.
- Linear infrastructure can bring significant social benefit but also cause exclusion. In countries like Canada and Australia, indigenous communities face significant disadvantages on account of poor infrastructure. In Ontario alone, the First Nations linear infrastructure gap is estimated at CA\$1.9 billion.¹⁶ The New South Wales Government has announced an AU\$54.8 million investment in the Roads to Home Program, aimed at upgrading critical infrastructure within discrete Aboriginal communities.¹⁷

1. Muller (2020)
 2. Committee on Climate Change (2018)
 3. Buglife - The Invertebrate Conservation Trust (2021)
 4. Network Rail (2020) (UK)
 5. Prateek & Sonia (2022)
 6. Robinson (2022)

7. University of Cambridge (n.d.)
 8. Directorate-General for Mobility and Transport (2021)
 9. Department of Foreign Affairs and Trade (2021) (AU)
 10. Infrastructure Australia (2017)
 11. Hern (2022)
 12. Fortune Business Insights (2022)

13. Komanoff (2021)
 14. Dulac (2013)
 15. World Health Organization (2022) (1)
 16. The Canadian Council for Public-Private Partnership (2016)
 17. NSW Aboriginal Land Council (n.d.)

GO

03

TAXONOMY OF CORRIDORS



Hassell project image: Level Crossing Removal Project, Werribee Street, Melbourne. Photography by Sarah Pannell

TAXONOMY OF CORRIDORS

Corridors generally exist to serve different users and uses by performing certain functions within a linear physical setting.

Often, corridors are designed with only one kind of user and function in mind, dictated by a narrow sector and its priorities; roads are designed to be conduits for drivers, railways to be conduits for trains carrying people and goods, rivers may be appropriated as sources of energy, and so on.

In this chapter, we present a common language to understanding corridors outside their traditional silos and physical delineations.

We believe that by dismantling corridors by their core users, uses, functions, and geometries, we may have a better chance of putting them back together again as more holistic, better integrated spaces.

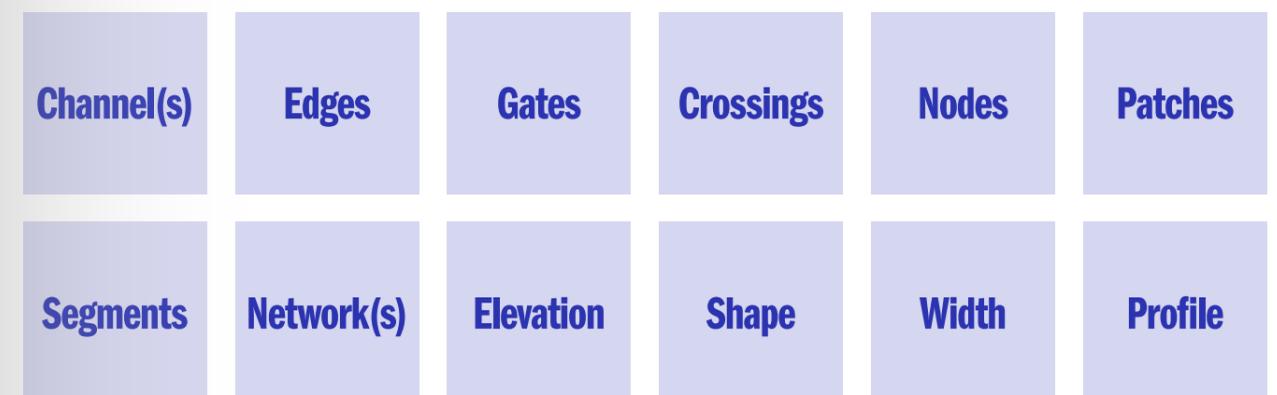
USERS & USES Why corridors exists



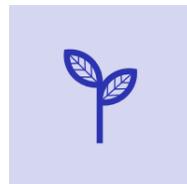
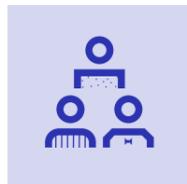
FUNCTIONS What corridors do



GEOMETRY & STRUCTURE How corridors work



Why do we need corridors, built and natural?



USERS

“One of my issues with corridor projects is that they are only designed with a primary user in mind, not with multiple levels of users in mind. The highway, for example, is exclusively about drivers.”

Stakeholder sentiment (anonymised)

1 PEOPLE

People – as individuals, communities, and populations – use corridors to move between different places of amenity, productivity, and interest.

In pre-Neolithic times, nomadic communities used natural corridors to travel to food and shelter. With the establishment of towns and cities, people started relying on built corridors for trade and commerce. Today, with the digitisation of many economic activities (including knowledge-based work) and the continued growth of urban conurbations, corridors are increasingly important as facilitators of social encounters and access to nature.

Transportation technology has enabled humans to travel further, faster, and at greater volumes than any other species on Earth.

HOW

People naturally move by walking. Transportation technologies have also enabled people to move by other means, such as by driving, cycling, sailing, etc.

VIA

Feet on trails/footpaths, cars/buses on roads, trains on rails, boats on canals/ivers, bikes on bike paths, etc.

2 WILDLIFE

Wildlife (mammals, fish, birds, reptiles, amphibians, and invertebrates) use corridors as conduits for species dispersal and migration, and as habitats for food, nesting, brooding, loafing, and protective cover.

The term ‘wildlife corridor’ refers to any linear feature in the landscape that can be used for migration or dispersal of wildlife, including pollinators. Enabling movement between habitats allows species to find food and mates, and escape natural disasters or human disturbances.

Wildlife corridors can be natural, such as river systems or forests, or man-made, such as wildlife overpasses or underpasses.

HOW

Wildlife naturally move by walking, swimming, flying, climbing, or crawling.

VIA

Natural and built green/blue corridors. Riparian corridors are used by 70% of all terrestrial wildlife species during some part of their life cycle.¹ Studies suggest that wildlife corridors for large mammals need to be at least 100 m wide to function effectively.²

3 PLANTS

Plants (herbs, shrubs, trees, climbers, and creepers) use corridors to disperse their pollen and seeds and colonise new areas, increasing gene flow and promoting species diversity within otherwise isolated areas.³

Ecological connectivity is essential for the survival of plant species. A research study conducted over an 18-year period found that corridors reduced the likelihood of plant extinction in patches by about 2% per year.⁴ However, many plant species can only benefit from corridors for long-distance dispersal if they can also use them as stepping stone habitats for growth and reproduction.

Plants often use corridors (especially their edges) as habitats, benefiting from the natural flow of nutrients.

HOW

Terrestrial plants are unable to move from one place to another, but their seeds and pollen may be carried by the wind, water, and animals like pollinators.

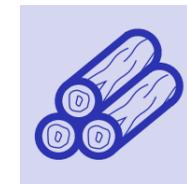
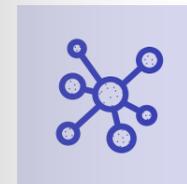
VIA

Natural and built green/blue corridors. Studies suggest that plant corridors should be at least 30 m wide to facilitate gene flow.⁵

1. United States Department of Agriculture (1999)
2. Bentrup (2008)
3. Tewksbury et al. (2002)

4. Damschen et al. (2019)
5. Bentrup (2008)

Corridors exist to connect people, wildlife, and plants, and to help ensure the healthy distribution of nutrients, resources, goods, and utilities between ecosystems.



USES

4 NUTRIENTS

Important nutrients contained in soil and water, such as nitrogen, carbon, phosphorus, sulphur, and potassium, are distributed between different ecosystems via corridors, especially waterways.

The movement and exchange of nutrients between different ecosystems forms nature’s recycling system. Both the injection and removal of nutrients is essential for plant and animal life. Some nutrients may also, in excess, be harmful. Today, most of the harmful levels of nutrients that can be found in our waterways come from human activities and sources, such as fertilisers, wastewater, automobile exhaust, and animal waste, creating serious ecological challenges.⁶

Healthy river corridors help tackle these challenges by transporting, filtering, and trapping nutrients for the benefit of downstream ecosystems.

HOW

Nutrients move through ecosystems in biogeochemical cycles, using living and non-living animals for transferral.

VIA

Any corridor that is exposed to the natural elements, such as green/blue corridors and open roadways and railways.

6. U.S. Geological Survey (2019)
7. World Trade Organization (n.d.)

5 RESOURCES

Renewable and non-renewable natural resources, such as water, food sources, minerals, fossil fuels, timber, and other raw materials, are transferred between habitats via corridors.

Built corridors typically transport resources from extraction sites (quarries, forests, grain fields, oil fields) to production facilities and consumption areas like cities and suburbs.

The use of corridors for resource distribution has enabled the establishment of habitats away from their sources of food, shelter, protection and, in the case of human settlements, economic activity.

The potential disruption of these corridors due to climate events or geopolitical factors poses a significant threat to settlements in resource-scarce regions.

HOW

People tend to move resources as freight using trains, trucks, vans, and cargo ships. Resources may also be carried in smaller quantities by humans and animals alike.

VIA

Trains on railways, trucks/vans on roadways, boats/barges on canals, and barges/ships on rivers.

6 GOODS

Capital and consumer goods and commodities, such as food products, clothing, furniture, home appliances, machinery, and electronic equipment, are transported between producers and consumers via corridors.

Goods are typically produced in factories and workshops located in industrial areas from where they must be transported via corridors to places of consumer access, such as shops and delivery points.

It is only humans who produce goods from resources and who need built corridors for goods distribution. Over the last two centuries, global trade of goods has grown exponentially, increasing the demand for built corridors and efficient supply chain systems.⁷

HOW

Goods can usually be moved by smaller transportation devices than resources, such as trains, trucks, cargo ships, vans, cars, barges, bikes, and autonomous air, water, or ground-based drones.

VIA

Trains on railways, trucks/vans/cars on roadways, boats/barges on canals, barges/ships on rivers, and bikes/micro-mobility modes on roads and pathways. Autonomous drones may use any corridor available.

7 UTILITIES

Utilities (electricity and natural gas, potable water and sewage, stormwater, waste recycling, and telecommunication) are transmitted between sources, habitats, and sinks/landfills via corridors.

Utilities support the everyday functioning of human activities undertaken in homes, businesses, and institutions, by providing heating, cooling, cooking, plumbing, waste removal, water management, and communication functions.

Utility corridors are essential for any modern human settlement. Passages for the distribution of utilities are often built underground or above ground.

In a circular economy, utilities may be recycled back into the habitat after use.

HOW

Liquid utilities are moved by a combination of pumping and gravity; electric currents are moved by transmission; solid utilities are carried by trucks, trains, and barges.

VIA

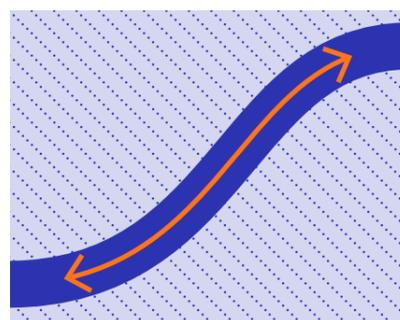
Pumping via pipes; transmissions via overhead and underground wires/cables; trucks, trains, and barges via roads, railways, and barges.

What are the different functions that corridors may perform for their diverse users and uses?

FUNCTIONS



Image: Adobe Stock



1 CONDUIT Moving in the corridor

As conduits, corridors move humans, wildlife, energy, water, nutrients, seeds, and other elements between different ecosystems.

Corridors fundamentally exist to facilitate the movement of people, wildlife, plants, nutrients, resources, goods, and utilities between different ecosystems, regions, and places of interest.

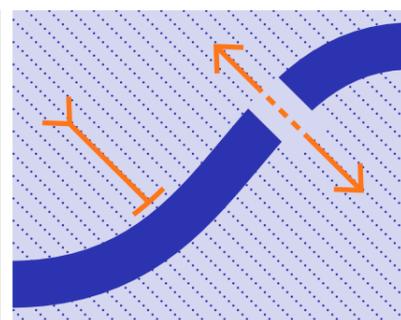
The corridor's ability to move matter is usually determined by the width and materiality of the interior movement channel. Several parallel channels with different design properties can also facilitate movement at different speeds.

Human inventions such as sluice-controlled canals, railways, and asphalt paving have significantly increased the scale and speed of corridors as conduits, enabling humans to move by e.g. boat, train, and car.

Simultaneously, there has been a degradation in the ability of natural corridors to connect wildlife and plants due to fragmentation and width reductions.

MEASURE

- Speed of movements
- Carrying capacity



2 FILTER Crossing the corridor

As filters (and sometimes barriers), corridors regulate the cross movement of humans and wildlife, and help to intercept wind, water, organisms, and nutrients.

The filtering effect of corridors can impact ecosystems for better and for worse.

By filtering sediments and agricultural chemicals, reducing wind velocities, and decreasing soil erosion, corridors help to protect and maintain local ecologies.

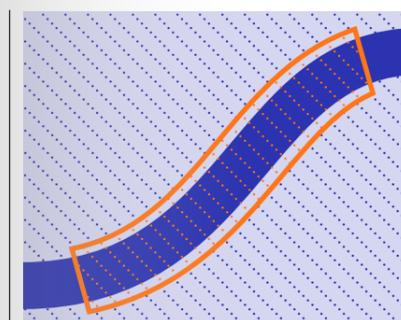
Corridors may also become barriers to movement, resulting in the isolation of habitats and communities.

Corridor crossings are facilitated by permeable edges and edge openings. Infrastructure such as bridges, tunnels, and overpasses enable people, wildlife, and goods to move safely across high-volume and high-speed corridors.

MEASURE

- Frequency of cross movements
- Severity of collisions

Corridors may act as conduits for movement, as filters for cross-movement, as habitats for all kinds of life, and as a sink or source of nutrients, resources, and utilities.



3 HABITAT Living in the corridor

As habitats, corridors provide permanent or temporary shelter to people, wildlife, and plants living within or on the edge of the main flow of movement.

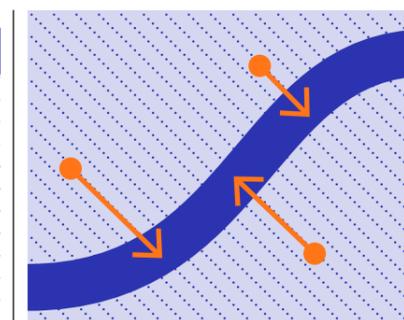
Natural corridors are often great sources of food, water, and nutrients, making them ideal places to live and thrive. Wildlife and plants may choose to live in the interior or on the edge of the movement channel. The wider the natural corridor, the greater the habitat quality; some studies suggest at least 2 km.¹

Early human habitats were also typically established on the edges of natural corridors.

Built corridors facilitating human activities rarely provide interior habitats, but often provide edge habitats in the form of e.g. railway and road verges. By increasing the edge-to-interior ratio, the habitat qualities of these corridors may be further improved for both natural and human settlements.

MEASURE

- Diversity of ecological, economic, and social systems
- Density of ecological, economic, and social activities



4 SINK What the corridor keeps

As sinks, corridors receive and retain objects and substances from the surrounding ecosystem, such as soil, water, industrial/agricultural chemicals, and waste products.

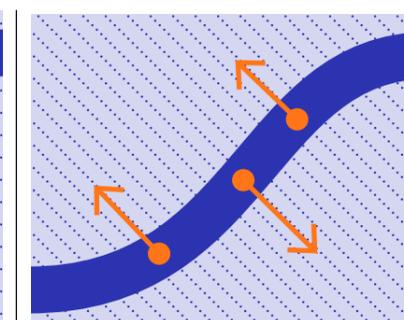
Corridors have the ability to accumulate and retain substances, which may be beneficial or harmful to the natural ecosystem.

The sink effect is especially prevalent in waterways, which play a critical role in removing excess nutrients and pollutants from the surrounding ecosystem. When the quality of natural corridors degrades it is often because of excess chemicals and waste produced by human activities.

Built corridors have rarely functioned as ecological sinks. However, new material technologies might change that, for example by enabling road surfaces to trap microplastics before they reach the groundwater.²

MEASURE

- Volume of substances/resources kept
- Types of substances



5 SOURCE What the corridor returns

As sources, corridors produce and release objects, substances, and resources, like energy, food, water, and raw materials into the surrounding ecosystem.

Rivers can produce hydroelectric power using dams and turbines. They also produce sediment, which can be used for construction, and support agriculture by providing irrigation and nutrients to crops grown along their banks.

Transportation corridors like roads and railways can be seen as sources of economic development through their movement of labour and materials. Transportation corridors also produce waste, such as discarded packaging and pollutants.

Underground railways produce vast amounts of heat through their operation. With new technologies, this heat may be captured and reused to generate energy and heat for buildings.³

MEASURE

- Volume of substances/resources produced
- Types of substances

1. Beier (2018)
2. Indacochea (n.d.)
3. Buddoo (2020)

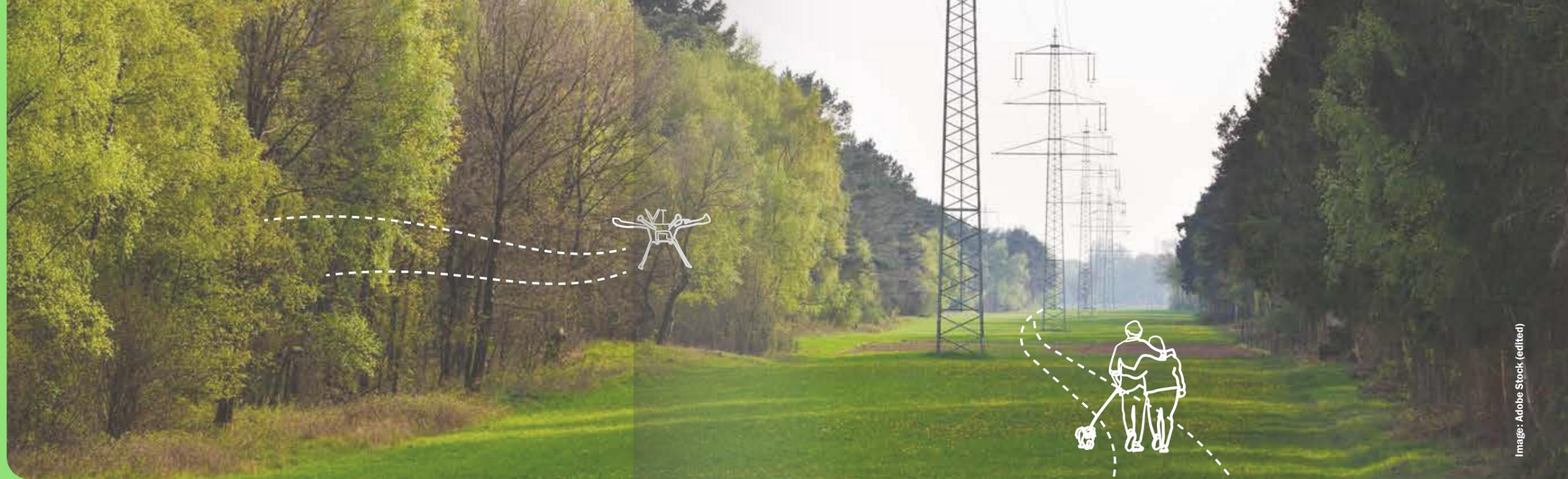


Image: Adobe Stock (edited)

EXAMPLES

By combining new users, uses, and functions, previously one-dimensional corridors may become more multifunctional. This shift in thinking is already happening in many parts of the world.



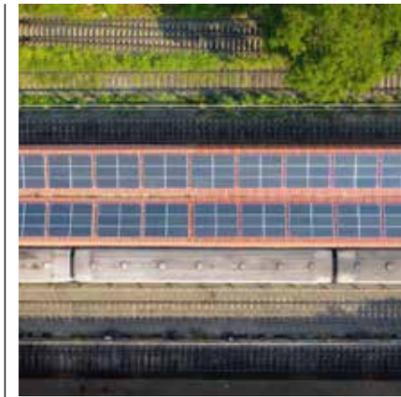
The High Line in New York is both a conduit for pedestrians and a habitat for 150,000 plants.



Wireless charging roads have been successfully tested in a number of countries, effectively turning the movement corridor into a source of energy.



With small clean-energy autonomous vehicles, greenways and canals may be used to facilitate last-mile goods deliveries alongside recreational activities.



Compact, efficient solar panels can now be utilised on railway station roofs and within available spaces along and between railway lines to harness solar energy effectively.



The River Vilaine in France integrates the world's largest assembly of floating ecosystem modules, providing an alternative means for green growth where land is limited.

Images: Adobe Stock

“The Glasgow City Region City Deal Avenues programme is reshaping urban corridors across Glasgow city centre to dedicate more space to people and active travel, nature-based and SMART solutions. The Avenues aim at merging sustainability with health and well-being objectives, transforming urban corridors in places, thus enabling a thriving civic life throughout the city centre.”

Paola Pasino, Principal Officer, Glasgow City Council

How does a corridor's geometry and structure determine its ability to perform a variety of functions in service of specific users and uses?



Image: Adobe Stock

PLAN GEOMETRY



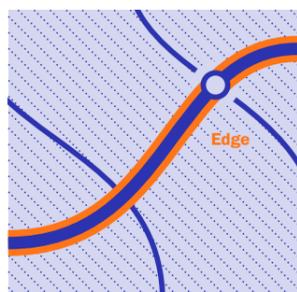
1 CHANNEL(S)

Also highway lane, railway track, navigation channel, transmission line, pipeline, utility passage...

- Corridors connect different nodes of activity via channels of movement.
- The channel determines the general speed, volume, and direction of movement that takes place within the corridor. Several channels may exist side-by-side.
- Channels often form where there are natural variations in the landscape, creating favourable conditions for movement.
- Built channels may also construct new movement corridors by overcoming natural barriers in the landscape.

MEASURE

- Connectivity (high/low)
- Horizontal alignment (straight/curved)



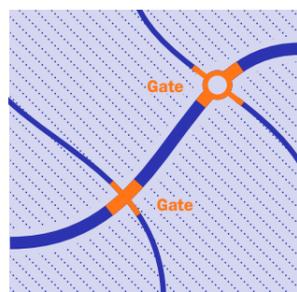
2 EDGES

Also fence, shoulder, verge, boundary, buffer, riparian zone, safety zone, ecotone...

- The interface between the channel and the patch is the corridor's edge zone.
- Edges can be very wide or virtually non-existent.
- If an edge is wide, it may function as its own ecosystem and habitat. If an edge is narrow, it may function as a filter between the channel and the patch.
- By capitalising on the positive friction that is created between the channel and the patch, the edge often develops its own unique properties.

MEASURE

- Permeability (high/low)
- Edge-to-interior ratio



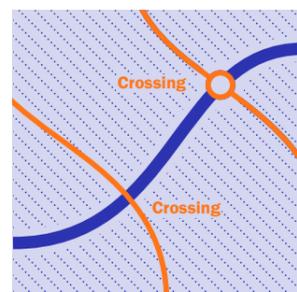
3 GATES

Also intersection, on-ramp/off-ramp, pier, junction, rail station, bus stop, power station...

- Gates are the points of entry and exit to the channel of movement.
- Gates can appear both at nodes and in-between nodes. A gate does not necessarily facilitate a crossing.
- Slow-moving corridors typically have more gates than fast-moving corridors, and are therefore often more accessible.
- Increasing the number of gates tends to have a negative impact on the speed of movement in the corridor, but a positive impact on the accessibility of the corridor.

MEASURE

- Accessibility (high/low)
- Frequency (high/low)



4 CROSSINGS

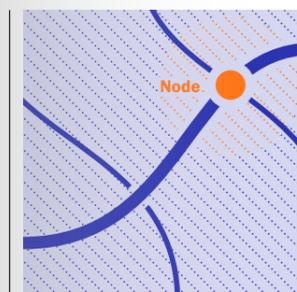
Also intersection, crosswalk, bridge, tunnel, viaduct, culvert, overpass, flyover...

- Crossings are routes that traverse the channel of movement and facilitate cross movement.
- Crossings can appear at nodes, in-between nodes, and at gates. Crossings do not necessarily facilitate access to the corridor.
- Fast-moving corridors typically need grade-separated crossings, while slow-moving corridors can facilitate crossings at grade.
- Crossings at the grade of the corridor can have a negative impact on the speed of movement, but a positive impact on the accessibility of the corridor.

MEASURE

- Accessibility (high/low)
- Frequency (high/low)

PLAN STRUCTURE



5 NODES

Also neighbourhood centre, market square, watering hole, saltlick, breeding ground...

- Nodes are made from clusters of activity or nucleated settlements, which form along the corridor or at its endpoints.
- Nodes tend to form in places where there is a natural congruence of resources and favourable conditions for life to survive and thrive.
- Nodes may also form in places where one or more corridors intersect, enabling the inflow and outflow of people, plants, wildlife, goods, and resources.
- Large, high-density nodes tend to rely on high-capacity corridors.

MEASURE

- Size (large/small)
- Density (high/low)



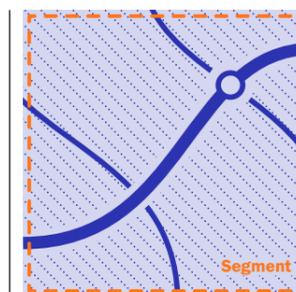
6 PATCHES

Also neighbourhood, district, forest, field, community, precinct, area...

- A patch is defined as a plant, animal, or human community with relatively homogeneous properties.
- Corridors tend to subdivide the landscape into patches. If a corridor hinders transverse movement between patches, it becomes a barrier.
- If a corridor separates patches with complementary properties, the effects may be harmful. Correspondingly, if a corridor separates patches with incompatible properties, the effects may be beneficial.

MEASURE

- Structure (simple/complex)
- Level of integration (high/low)



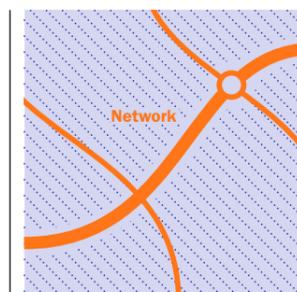
7 SEGMENTS

Also section, portion, fragment, catchment, watershed, subdivision, region...

- Corridors are often divided into segments representing significant changes in context.
- Segments are usually created by natural ecological and geographical divisions or by artificial divisions determined by land ownership and governance structures.
- When land ownership and governance segments do not align with natural ecological and geographical segments, it can create challenges for addressing the corridor holistically.
- Corridor segments can also relate to the scale of the movement channel, demarcating shifts from roads to streets or rivers to streams.

MEASURE

- Scale (local/regional)
- Relative length (short/long)



8 NETWORK(S)

Also system, grid, web, mesh...

- Several intersecting corridors and their nodes form networks. Most corridors are part of a wider network.
- Networks can be high-density or low-density. In a high-density network, every node is connected to every other node, and there are more corridors per node overall.
- Networks can also be small-scale or large-scale. In a large-scale network, the distance between the nodes is greater, and there are more linear kilometres between nodes.
- At the urban scale, networks tend to be high-density and small-scale. Between nodes and at the regional scale, networks tend to be low-density and large-scale.

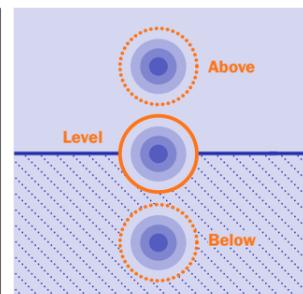
MEASURE

- Density (high/low)
- Scale (local/regional)

All corridors consist of the same core components, which may be shaped and arranged in innumerable ways. The corridor's ability to deliver holistic outcomes largely depends on the design and make of each component and the relationship between them. There is no one-size-fits-all.



SECTION GEOMETRY



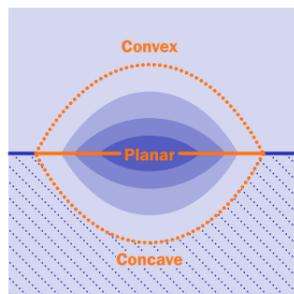
9 ELEVATION

Corridors can activate a linear space above ground, at ground level, or below ground.

- Elements implemented at the ground level tend to create the greatest levels of friction between the channel, edge, and patch, especially for walking life.
- Elements implemented above ground may be a conduit or barrier for birds, pollinators, and other flying creatures.
- Elements implemented below ground may impact the distribution and quality of soil nutrients and ground water.
- Corridor construction costs and timelines tend to vary greatly depending on the elevation of the corridor.

MEASURE

- Elevation (above ground, at ground level, below ground)



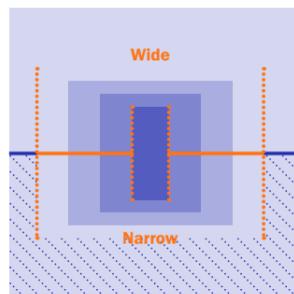
10 SHAPE

Corridors can be designed as convex, planar, or concave linear structures.

- Concave structures create some barrier effects but are visually less intrusive than convex structures.
- Concave structures also increase the corridor's ability to act as an ecological sink, as evidenced by natural waterways.
- Planar structures reduce the corridor's barrier effects but may increase the risk of collision between channel movements and cross corridor movements.
- Convex structures increase the corridor's physical and visual barrier effects.

MEASURE

- Shape (convex/planar/concave)



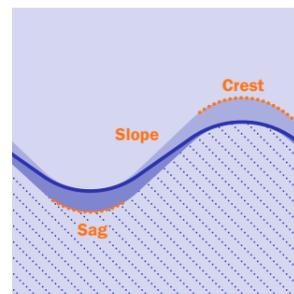
11 WIDTH

Corridors can be narrow or wide linear structures relative to their length and use.

- The width of the channel is usually measured in comparison to the length of the corridor (perimeter-to-area ratio).
- Wide channels tend to facilitate better movement along the channel and poorer movement across the channel.
- Wide, slow-moving corridors are more likely to function as ecological habitats, while narrow, fast-moving corridors tend to function primarily as conduits.

MEASURE

- Width (wide/narrow)
- Perimeter-to-area ratio



12 PROFILE

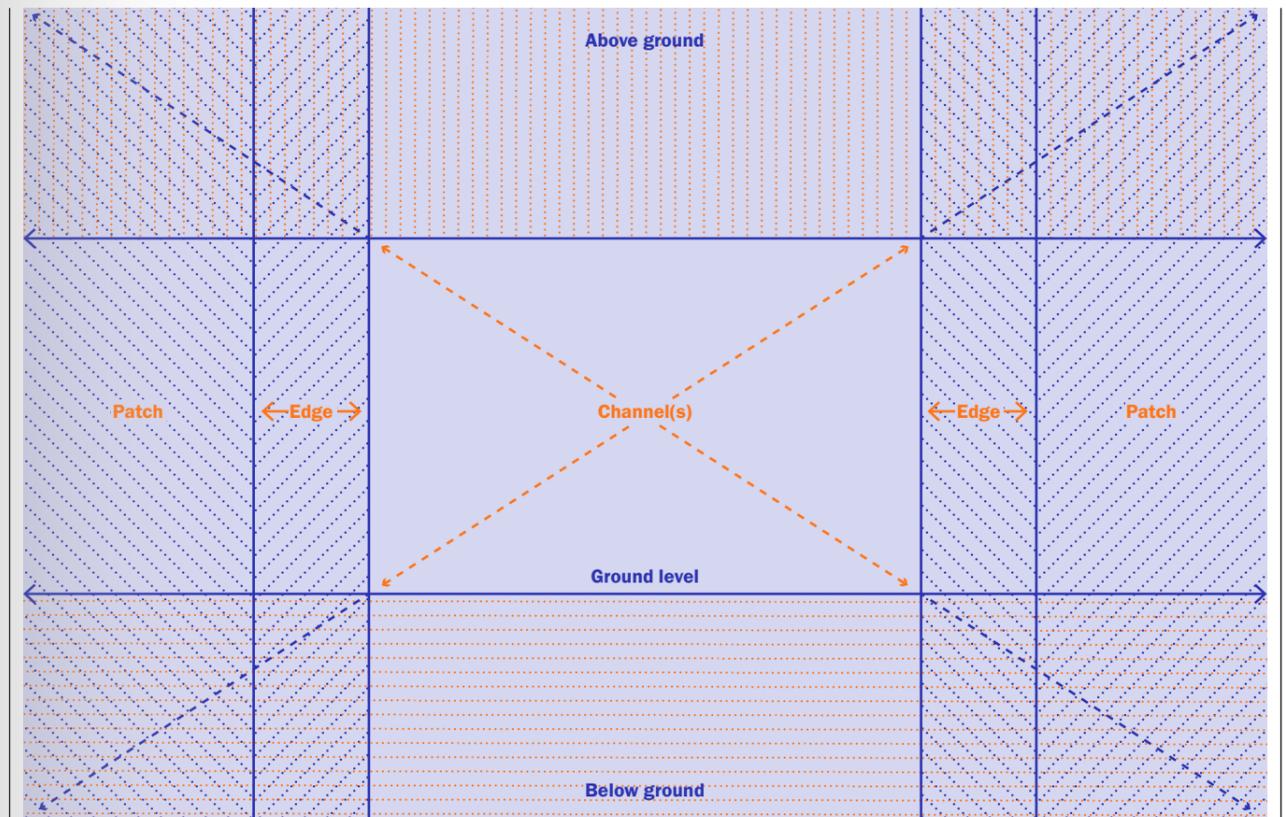
Corridors may have a straight or curved profile determined by the number of crest and sag curves.

- The corridor's profile is often determined by the landscape.
- The vertical alignment of the corridor determines the general direction of movement in the channel: upwards or downwards.
- The vertical alignment of the corridor is usually measured by crest and sag curves, which relate to the elevation of points along the channel.
- Movement speeds are usually highest at the bottom of a sag vertical curve and slowest at the top.
- The corridor is more likely to function as a sink when the curve sags.

MEASURE

- Vertical alignment (sag curves/crest curves)
- Slope gradient

SECTION STRUCTURE



MATRIX SECTION

The matrix section considers the corridor in its entirety, from the centre of movement and outwards in every direction. Each field is an opportunity for maximising the utility of the corridor and minimise negative friction between spaces with different conflicting properties.

- Every 'field' in the diagram presents an opportunity for activating the full matrix of the corridor, which includes both the channel, its edges, and the patches that surround it.
- If the corridor is being designed in a built-up area, the matrix section may serve as a tool for mapping existing geometries and structures that the linear space will interact with.
- The matrix section will usually vary for different segments of the corridor, and its functional remit will often be broader than the narrow site boundaries that tend to delineate linear infrastructure projects.

ONE LANGUAGE, NUMEROUS POSSIBILITIES

By creating a shared taxonomy of corridors, it becomes easier to facilitate discussions about the intended purpose of linear spaces and their corresponding design attributes, promoting effective communication across various sectors.

Built corridors and natural corridors vary in the type of value they generate, as a result of the qualities that define them.

These qualities are dependent on the corridor's users, uses, functions, geometry and structure. With time and scale, these defining qualities have resulted in the formation of silos, and with the evolution of siloed systems has come the emergence of a range of collateral issues.

Unforeseen problems that have arisen as a result of the evolution of silos include: community displacement, habitat fragmentation, and climate disruption, making apparent how the economic and social positives of one approach may simultaneously present social and environmental challenges.

Not all evolution is bad however. The evolution of technology has, for example, enabled the integration of data cabling into our corridor networks, re-iterating the potential for a more holistic, multifaceted future for corridor design.

Alongside technology, there are other drivers of change, which are assisting the paradigm shift from a siloed to a holistic approach, including climate change, global politics, and changing economic and social trends.

The move towards a redefinition of corridors is already underway in many parts of the world.

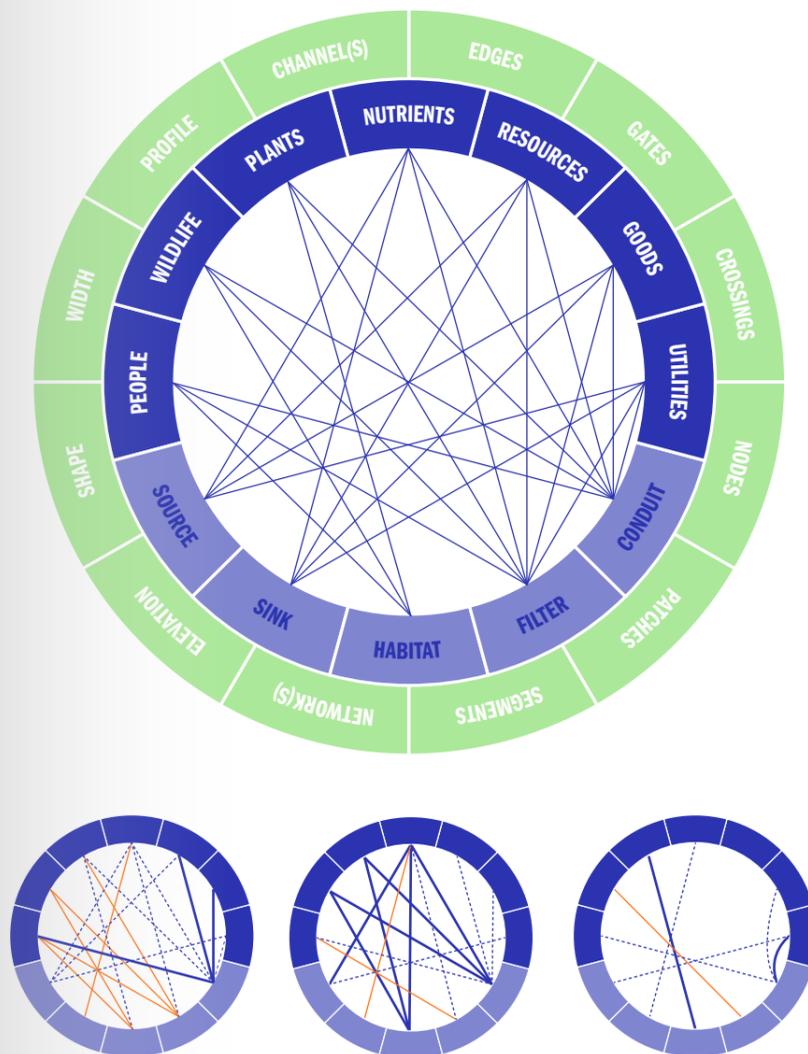
To help us understand how we might redefine approaches to corridor design, we can interrogate how

their individual taxonomies might limit certain abilities and encourage others.

The diagram overleaf has been designed as a discussion tool to help stakeholders map potential relationships between users, uses, and functions within the corridor ecosystem.

In doing so, it is crucial to consider the corridor beyond its 'channel', as an integrated linear space acting in synergy with its neighbourhood spaces. The language we have set forward is intentionally sector-agnostic, to enable these conversations to take place across different organisational silos.

MAPPING RELATIONSHIPS



Corridors may benefit up to 25 different combinations of users, uses, and functions.

The corridor's geometry and physical structure determines the extent to which these opportunities may technically be unlocked.

Other context-specific barriers and enablers, such as leadership, finance, and operations, are discussed in the following chapters.

Exercise

Map potential positive links, negative links, and missed links in an exercise to determine the multifunctional potential of the corridor.

- Potential link
- Positive link
- Negative link
- - - Missing link

Illustrations

Order of left to right.

Roadways

A typical road works well as a conduit for people, goods, and resources, but poorly as a filter and habitat for people, wildlife, and plants.

Waterways

A typical waterway works well as a conduit and habitat for wildlife and plants, but presents missed opportunities for the movement of goods and filtering of nutrients.

Overhead power lines

Overhead power lines are effective conduits of utilities and sometimes good habitats for plants, but also a dangerous filter for avian wildlife.

04

CARING FOR CORRIDORS

CIRCUIT

ONE SIZE FITS ONE

“Silos tend to be round and circular and people get locked in them.”

Stakeholder interview quote (anonymised)

SECTOR OVERVIEW

1 Roads & road-based transport corridors



PRIMARY USE TODAY Conduit for people and goods moving in wheeled vehicles like cars and trucks on a smoothed or paved surface.

BRIEF HISTORY The first paved roads were built in 4,000 BCE. Sharp increases in motor vehicle usage spurred the first developments of motorways/highways in the US and Europe in the early 1900s.

MANAGEMENT Highways are typically owned by state bodies with some urban roads under local authority ownership or management. Some inter-urban roads may be managed by private companies.

SPEED OF MOVEMENT Average speeds range from between 30 km/h in built-up areas to 120 km/h on inter-urban roads/highways.

WIDTH OF CHANNEL A standard lane width ranges from 3–3.7 metres. The widest highway in the world (Houston’s Katy Freeway) is 26 lanes across.

CAPACITY One standard lane carries circa 2,000 people/hour travelling by car or 9,000 people/hour travelling by a regular bus service.

CARBON EMISSIONS 192g CO₂e per passenger kilometre (medium petrol car).¹ 75% of global transport emissions come from road vehicles.²

STRENGTHS

- Personal mobility freedom
- Extensive existing network
- Economic development

WEAKNESSES

- Costs (space, carbon, capital, time)
- Congestion when used at scale
- Air and noise pollution

2 Rail & rail-based transport corridors



PRIMARY USE TODAY Conduit for people and goods moving in flange-wheeled vehicles like trains and carriages running on steel rails.

BRIEF HISTORY Modern rail transport originated with the steam-powered locomotive in the early 1800s and peaked in use and popularity in the early 20th century.

MANAGEMENT Railways are often owned by national governments and run by dedicated management authorities or private operating companies.

SPEED OF MOVEMENT Average speeds range from 25–40 km/h (urban metro systems) to ~220–270 km/h (high speed rail).

WIDTH OF CHANNEL Gauge widths vary between 1.0–1.6 metres, while the entire corridor is typically 3–15 metres wide, including safety zones.

CAPACITY One light rail lane carries circa 20,000 people/hour, while a standard heavy rail track may carry up to 80,000 people/hour.

CARBON EMISSIONS 41g CO₂e per passenger kilometre (on national rail).³ Only 1% of global transport emissions come from rail travel.⁴

STRENGTHS

- High-speed & high-capacity
- Carbon-efficient
- Transport-oriented development

WEAKNESSES

- Construction costs & disruption
- Safety protocols & risk management
- Barrier-effects

3 Power, gas, & fibre utility corridors



PRIMARY USE TODAY Conduit for supplying common utilities to human settlements, transported via pipelines and underground or overground cables.

BRIEF HISTORY Utility corridors in the form of today’s national grids emerged during the industrial revolution. The first transatlantic telegraph cable was laid in the mid-19th century.

MANAGEMENT Electricity distribution utilities are primarily state-owned, with more private ownership (~40%) in high-income countries.⁵ Telecom cables are predominantly privately owned.

SPEED OF MOVEMENT Electricity travels at ~270,000 km/h; gas at ~72 km/h. Fiber internet transmits data at close to the speed of light.

WIDTH OF CHANNEL 26–42 m for overhead transmission lines; ~10 m for gas pipeline corridors. Additional safety zones vary between 10–80 m.

CAPACITY Not applicable / significant variations apply.

CARBON EMISSIONS Leading bottlenecks of CO₂ emission in the U.S. consist of oil (47%) and natural gas (44%) pipelines, often due to leakages.⁶

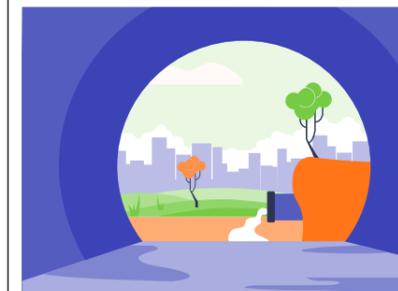
STRENGTHS

- Infrastructure backbone
- Economic growth
- Minimum wildlife interference

WEAKNESSES

- Easily disrupted (weather, climate, terror)
- Transmission losses
- Aging infrastructure

4 Water supply and drainage corridors



PRIMARY USE TODAY Conduit for circulating potable and non-potable water, transported via water pipes, sewer pipes, and storm drain tunnels.

BRIEF HISTORY Primitive water systems have existed for thousands of years as a means to protect populations from disease. Modernisation commenced in the 17th century.

MANAGEMENT Water services are often operated by a dedicated public, private, or PPP company. Due to mismanagement, private owners are facing increased scrutiny.⁷

SPEED OF MOVEMENT Speeds are often determined by gravity. Maximum velocities in pipes typically range from range from 0.5–3 m/s.

WIDTH OF CHANNEL 15–500 mm for pipes; 2–6 m for sewer and stormwater easements; the width of open watercourses can vary significantly.

CAPACITY Not applicable / significant variations apply.

CARBON EMISSIONS ~200 t CO₂/year per km of potable water pipeline; Water use, storage, and distribution is responsible for 10% of global GHG emissions.⁸

STRENGTHS

- Critical resource distribution
- Public health & sanitation
- Flood management

WEAKNESSES

- Operating costs
- Pollution from leakages
- Resource scarcity

5 Waterways & green corridors



PRIMARY USE TODAY Conduits for people and small goods moving on foot or via small vehicles; conduits and habitats for wildlife and plants.

BRIEF HISTORY Natural blue and green corridors are the oldest form of linear infrastructure. Most canals were built in the 18th century to serve heavy industry. Today these spaces are primarily recreational.

MANAGEMENT Waterways and green corridors are often managed by multiple local authorities or a single non-profit organisation. Many corridors also lack a dedicated management regime.

SPEED OF MOVEMENT Boats typically travel at speeds around 4–13 km/h. Autonomous drones have the potential to travel even faster (future).

WIDTH OF CHANNEL Built canals are typically 15–25 m; the width of natural rivers and green corridors can vary significantly, from ~ 5 to over 300 metres.

CAPACITY Vessels can have a cargo capacity exceeding 1,000 tonnes compared to a maximum lorry payload of about 25 tonnes.⁹

CARBON EMISSIONS <0 CO₂e; e-bike use emits around ~10g CO₂e per passenger kilometre; shipping generally emits less carbon/kg/km than road freight.¹⁰

STRENGTHS

- Biodiversity & pollination
- Recreational value & public health
- Naturally carbon-positive

WEAKNESSES

- Ecological degradation
- Maintenance costs
- Land use conflicts

1. Department for Business, Energy & Industrial Strategy (2019) (UK)
 2. IEA & ICCT (2020)
 3. Department for Business, Energy & Industrial Strategy (2019) (UK)
 4. IEA & ICCT (2020)

5. Alkhezam et al. (2018)
 6. Pascaris & Pearce (2020)
 7. Vidal (2015)

8. Water UK (2021)
 9. Inland Waterways Association (n.d.)
 10. European Environment Agency (2021)

HOW DO YOU MEASURE THE SUCCESS OF A CORRIDOR?

To better understand how corridors are managed, we looked at the vision, mission, and purpose statements of 70 infrastructure agencies across four regions.

Together, these agencies manage an estimated 5 million linear kilometres, equivalent to more than 100 trips around the world.

Safety emerged as the key objective overall, followed by sustainability and community.

In this analysis, we take a closer look at the shared objectives that bring sectors and regions together, and the differences that keep them apart.

TOP 12 AGENCY OBJECTIVES



NOTES The analysis references the vision, mission, and purpose statements of 70 infrastructure agencies across North America (primarily California and New York State), Australasia, Asia (primarily China, Hong Kong, and Singapore), Europe (primarily the UK & Ireland). The results have been weighted by country and sector. Several agencies operate in more than one sector and region.

The delivery of linear infrastructure takes a different focus from region to region, as environmental, economic, and political circumstances vary. Even when objectives appear similar, they are often formed by vastly different, entirely context-specific drivers.

In this section, we examine how objectives may differ across various parts of the world.

Our analysis of infrastructure agency objectives focuses on four key regions: Asia (including China, Singapore, and Hong Kong), Australasia (encompassing Australia and New Zealand), USA (specifically California and New York State), and Northern Europe (primarily the United Kingdom and Ireland).

The representation of agencies is most extensive for Australia and the United Kingdom, while it is smaller for Asia and North America. This discrepancy can be attributed, in part, to an English language bias, organisational variations, and differences in the availability of online information. To address these disparities, we complement our findings by incorporating insights from primary stakeholder interviews and secondary literature.

Shared focus on the environment with varying incentives for action.

Across all four regions, agencies consider environmental impact and ecological restoration as central factors, with shared drivers for action being the heightened risk of flooding and extreme weather events.

In warm and arid regions like California and Australia, the threat of wildfires also holds significant importance due to extended periods of drought, which render the landscape susceptible to

conflagration. The declining quality of linear assets further contributes to these vulnerabilities.

In the UK and Ireland, a noteworthy emphasis is placed on reversing the loss of biodiversity. Prominent landowners, including Network Rail, are presenting comprehensive action plans and ambitious targets to enhance the abundance and variety of plants and wildlife within the lineside estate.¹

In China, environmental targets are often linked to economic incentives, exemplified by President Xi Jinping's 'two mountains theory'. By stating that "clear waters and green mountains are as valuable as gold and silver mountains,"² the Chinese government is setting the tone for catalysing economic growth through ecological restoration.

Delivering world-class services in different regions.

Assessing agency performance is a key focus in all the studied regions, although there are differences in both measurement and implementation approaches.

Agencies in North America tend to be concerned with their safety, reliability, and efficiency record first, while Northern European and Australasian agencies are more likely to be reporting operational carbon emissions and social value initiatives.

In Asia, several of the reviewed agencies strive to deliver a service

that is efficient or simply best in class. For instance, Hong Kong's Drainage Services Department envisions "to provide world-class wastewater and stormwater drainage services enabling the sustainable development of Hong Kong."³

The provision of customer-centric services appears to be a relatively important priority in every region.

United around the UN's Sustainable Development Goals.

The leading drivers in each region naturally reflect local environmental, economic, and political conditions. This context-specific approach is of course sensible, as long as wider and global impacts are not forgotten. To address global objectives, many agencies have adopted the UN's Sustainable Development Goals.

For example, the UK's Department of Transport measures its contribution towards goals 4 (quality education), 8 (decent work and economic growth), and 11 (sustainable cities and communities).⁴ In Australia, Melbourne Water has committed to delivering against goals 6 (clean water and sanitation), 11 (sustainable cities and communities), 13 (climate action), and 15 (life on land).⁵

Looking beyond regional differences, it remains critical for agencies to adopt a shared understanding of how linear infrastructure impacts communities and ecologies at the global scale.

1. Network Rail (2020) (UK)
 2. Geall (2017)
 3. The Government of the Hong Kong Special Administrative Region (n.d.)

4. Department for Transport (2021) (UK)
 5. Melbourne Water (2019)

AGENCY OBJECTIVES IN FOUR REGIONS

N AMERICA 15 AGENCIES	N EUROPE 24 AGENCIES	SE & E ASIA 16 AGENCIES	AUSTRALASIA 23 AGENCIES
SAFETY	SUSTAINABILITY	EFFICIENCY	COMMUNITY
RELIABILITY	COMMUNITY	COMMUNITY	SAFETY
EFFICIENCY	SAFETY	SAFETY	SUSTAINABILITY
CUSTOMERS	ENVIRONMENT	SUSTAINABILITY	CUSTOMERS
SUSTAINABILITY	CUSTOMERS	HIGH-QUALITY	CONNECTIVITY
COMMUNITY	RELIABILITY	LEADERSHIP	HEALTH
WORKFORCE	ECONOMY	CUSTOMERS	ENVIRONMENT
ENVIRONMENT	EFFICIENCY	ENVIRONMENT	ECONOMY
LEADERSHIP	FUTURE-PROOF	MAINTENANCE	EFFICIENCY
QUALITY-OF-LIFE	HEALTH	HARMONY	FUTURE-PROOF
AFFORDABILITY	PROSPERITY	INNOVATION	INCLUSION
CLEAN	MAINTENANCE	LIVEABILITY	INTEGRATION
CONNECTIVITY	ACCESSIBILITY	WORLDCLASS	PLACE
ECONOMY	FAIR	CARE	RELIABILITY
INCLUSION	HIGH-QUALITY	COMPETITIVE	PROSPERITY
INNOVATION	LEADERSHIP	CONNECTIVITY	WORLDCLASS
MAINTENANCE	LIVEABILITY	ECONOMY	WORKFORCE
MOVEMENT	SECURITY	EFFECTIVE	LEADERSHIP
COMPETITIVE	SOCIETY	WORKFORCE	LIVEABILITY
EXCELLENCE	STAKEHOLDERS	EXCELLENCE	MAINTENANCE
FAIR	VALUE-CREATION	INTEGRATION	MODERN
FUTURE-PROOF	WORLD-CLASS	MOVEMENT	RECOGNITION
HIGH-QUALITY		RECOGNITION	SMART
RESIDENTS		TECHNOLOGY	VALUE-CREATION
RETURN ON INVESTMENT		BUSINESSES	
SEAMLESS		COORDINATION	
SPEED		COST-EFFECTIVE	
TRUST		FRIENDLY	
WORLDCLASS		HEALTH	
		OPENNESS	
		PROFESSIONAL	
		RETURN ON INVESTMENT	
		SHAREHOLDERS	
		SMART	
		SOCIETY	

NOTES The analysis references the vision, mission, and purpose statements of 70 infrastructure agencies from across North America, Australasia (Australia & New Zealand), Asia (China, Hong Kong, and Singapore), and Europe (primarily the UK & Ireland). Some agencies operate in more than one region. The words are scaled by their relative number of mentions by region. Words which have been mentioned by fewer than 10% of the agencies within a region are not included.

TOP FIVE OBJECTIVES BY SECTOR

ROADS & ROAD-BASED TRANSPORT



100% — 24 AGENCIES

Safety is at the top of the agenda for 17 out of 24 road management agencies. Many are also keenly focused on delivering a reliable service for their primary customers (namely drivers), in the most sustainable manner possible.

RAIL & RAIL-BASED TRANSPORT



100% — 26 AGENCIES

18 out of 26 agencies in the rail sector are on a mission to provide a safe service. They are also often focused on passengers and enhancing regional connectivity for the benefit of communities.

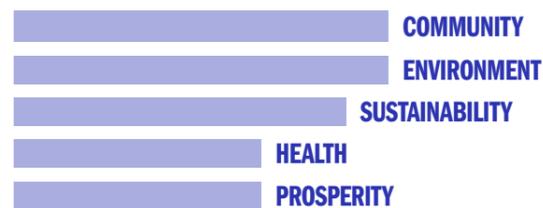
POWER, GAS, & FIBRE



100% — 12 AGENCIES

7 out of 12 power, gas, and fibre providers are focused on safety first. Providing efficient, reliable, and sustainable services is also high on the agenda, ideally while exhibiting industry leadership.

WATER & SEWERAGE



100% — 17 AGENCIES

9 out of 17 agencies in the water sector mention communities and the environment in their vision or mission statements. The sector is generally more environmentally focused than the transport sectors, with a particular emphasis on health and prosperity.

WATERWAYS



100% — 13 AGENCIES

A focus on communities is the common denominator for 8 out of 12 agencies managing waterways (not water supply). The sector is also concerned with managing resources efficiently and safely, while enhancing the environment and creating a sense of place.

NOTES The analysis references the vision, mission, and purpose statements of 70 infrastructure agencies across the roads, rail, utility, and waterways sectors. Some agencies operate in more than one sector.

Safety tends to be the main concern of the transport and dry utilities sectors, while agencies managing water resources are more likely to have communities front of mind.



Safety reigns in the road, railway, and dry utilities sectors, where the dangers also loom large.

Road accidents

Road traffic injuries are the leading cause of death globally for children and young adults aged 5–29 years.¹

Safe railways

The risk of death for a train passenger within the EU-27 is relatively low at one fatality for every 22 billion passenger kilometres.²

Power line collisions

Transmission-level voltages on power lines are often fatal to people and wildlife alike. It is estimated that collisions with overhead power lines kill between 12 and 64 million birds in the US annually.³



All sectors have sustainability strategies, but roads and utilities face the toughest starting point.

Road emissions

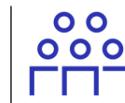
The roads sector accounted for more than 28% of CO₂ emissions from end-use sectors in 2021.⁴

Wastewater treatment

42% of household wastewater is not treated properly, damaging ecosystems and human health.⁵

Pipeline leakages

Methane emissions from leaking natural gas pipelines is a major concern world-wide. More than 260 billion cubic metres of natural gas is wasted due to pipeline bottlenecks and methane leaks globally today.⁶



Communities are the primary focus of agencies which manage waterways for utility and recreation.

Healthy canals

Living near well-maintained water bodies brings significant health benefits. Deprived communities can reduce their risk of developing chronic life-shortening diseases by up to 15% if they live within 700 m of a well-developed canal.⁷

Community isolation

1 billion people live more than 2 km away from a usable road, where lack of access is linked to poverty.⁸

Safe drinking water

Approximately 2 billion people around the world do not have safely managed drinking water services.⁹



1. World Health Organization (2022) (2)
 2. European Union Agency for Railways (2022)
 3. Loss et al. (2014)
 4. International Energy Agency (n.d.)
 5. UN Water (2023)

6. International Energy Agency (2023)
 7. Tiegies et al. (2022)
 8. Muller (2020)
 9. World Health Organization (2022) (3)

Safety is a key concern for most linear infrastructure agencies worldwide – and for good reason.

“The agency is very risk averse. When we propose additional uses, the easiest thing for them to say is: no.”

Stakeholder interview quote (anonymised)

Corridors pose a variety of threats to the health and safety of human and ecological life.

Acting simultaneously as conduits and barriers, linear spaces often bring different types of users into conflict with one another. Additionally, corridors may be vulnerable to the risk of disruption caused by, for example, extreme weather events, accidents, or even acts of terrorism.

Safety issues associated with linear infrastructure include:

- Risk of collision
- Increased pollution
- Route & service obstruction
- Habitat destruction
- Poaching & illegal harvesting

Consequently, safety tends to be high on the agenda for most infrastructure agencies, particularly in the roads, rail, and utility sectors.

Network Rail (UK) has, for example, set a mission to run a “safe, reliable, and efficient railway”, while the

mission of MetroLink (USA) is to provide a “safe, efficient, dependable and on-time transportation service”.

Roads are the most dangerous type of corridor. Globally, approximately 1.3 million people die each year as a result of road traffic crashes.

As the more vulnerable road users, pedestrians, cyclists, and motorcyclists account for more than 50% of these deaths.¹

By comparison, the International Union of Railways ‘only’ reported about 1,700 significant rail transport accidents resulting in 875 fatalities across 33 member countries in Europe, Asia, and the Middle East in 2021.²

Estimates from Great Britain suggest that rail is about 20 times safer than travelling by car.³ Trespassing is generally the main cause of railway accidents, followed by collisions at level crossings.⁴

Out of all the linear infrastructure types, roads also pose the greatest mortal danger to wildlife.⁵

It is estimated that 194 million birds and 29 million mammals die each year on Europe’s roads,⁶ while up to 10 million animals may be killed annually by road users in Australia.⁷

Many species are also found as victims of collisions with trains, though studies about wildlife mortality on railway tracks are few and far between. The same is true of utility corridors.

By increasing pollution, obstructing migration routes, and destroying habitats, corridors can also create significant environmental hazards.

Studies have found that the noise, light, and vibrations created by corridor traffic can significantly interfere with the ability of reptiles, birds, and mammals to communicate, detect prey, and avoid predators.⁹



Hassell case study: Level Crossing Removal Project at Cherry Street, Melbourne. Photography by Sarah Pannell

Humans are impacted by some of these nuisances too. In England, 2014 estimates suggest that the social cost of urban road noise could be in the range of £7–£10 billion per annum.¹⁰

There is an urgent need to raise awareness of these secondary dangers, which may impact design solutions and investment priorities.

Most infrastructure agencies are highly focused on safety, but few consider the full spectrum of risks and vulnerability equally.

Often, the interpretation of what constitutes a ‘safe’ corridor is skewed in favour of the corridor’s end users and operational personnel. For example, when trade-offs involving speed, capacity, and barrier effects arise, the former two usually win out.

One of the primary safety concerns for infrastructure operators is the risk of collisions.

The most common design solution to address this issue is the implementation of barriers, such as fences and guardrails, often at the expense of cross-corridor movement.

Another, albeit more costly, alternative involves the separation of different types of movement by grade. This approach has recently been adopted in Melbourne, Australia, as part of the Level Crossing Removal Project, which aims to eliminate 110 hazardous crossings from the greater Melbourne region by 2030.¹¹

Trees located near fast-moving corridors are frequently viewed as an unnecessary hazard due to the risk of falling limbs. However, their presence can help mitigate crucial risks, such as those posed by global heating. Embracing a more holistic perspective on safety necessitates equal consideration of short-term and long-term threats.

Safe by design

Safety can be achieved in a number of ways, including by lowering speed limits, barring access to the movement channel, and separating users across different levels.

These strategies do, however, come with significant trade-offs, particularly in terms of efficiency, accessibility, and financial cost.

Future technologies such as virtual fences and autonomous vehicles may help reduce the risk of collision without increasing barrier effects.

Safety needs to be considered for every type of user (people, wildlife, plants) across every function (conduit, barrier, habitat, sink, source).

1. World Health Organization (2022) (2)
 2. International Union of Railways (2022)
 3. Rail Safety and Standards Board (2021)
 4. International Union of Railways (2022)

5. Wingard (2014)
 6. Grilo et al. (2020)
 7. NRMA (2022)
 8. Loss et al. (2014)

9. Gregory et al. (2021)
 10. Dickens et al. (2014)
 11. State Government of Victoria (2022). Hassell’s involvement in this project has been summarised in the case study section in Chapter 5.

Sustainability has risen to the top of the agenda everywhere – the long journey to net zero has begun.

“Since the department pledged to become carbon neutral by 2030, sustainability is the primary focus across all the projects we deliver.”

Stakeholder interview quote (anonymised)



Hassell case study: Southern Expressway corridor landscaping, Adelaide. The extensive planting scheme included 250,000 native plants. Photography by Simon Stanbury

Linear infrastructure can create both challenges and opportunities for the long-term health and well-being of people, wildlife, and plants.

As the damaging effects of climate change are increasingly felt, sustainability has risen to the top of the agenda across the world, shaping government policy, business priorities, and customer choices alike.

Some of the main sustainability challenges that will need to be addressed by the linear infrastructure sectors include:

- Habitat fragmentation
- Biodiversity loss
- Greenhouse gas emissions from construction, use, and maintenance
- Land use and resource consumption
- Pollution and water management

The focus on delivering sustainable services is particularly pronounced in the transport and utility services sectors. South Australian Water

has, for example, set a vision to deliver “trusted water services for a sustainable and healthy South Australia”, and Transport Scotland has set out to create a “sustainable, inclusive, safe, and accessible transport system”.

Corridors may be a source of pollution through their construction, maintenance, operations, and use.

With many agencies outlining net zero goals, user emissions are often the most challenging factor to reconcile – especially in the roads sector, which accounted for more than 28% of CO₂ emissions from end-use sectors in 2021.¹

Additionally, roads are a source of particle pollution from tyre wear, which some studies suggest are 2,000 times more damaging to the environment than exhausts.²

The Net Zero strategy put forward by National Highways (UK) directly

reflects the issue of end-user emissions. The strategy sets a goal of eliminating emissions from corporate activities by 2030 and from maintenance and construction activities by 2040. However, the attainment of net-zero emissions from user activities is only expected by 2050.³ Meanwhile, the ongoing construction and expansion of roadways worldwide continue to attract new users and increase travel miles, further exacerbating the challenge of addressing end-user emissions.

By comparison, user emissions in the rail sector are considerably lower and on a positive trajectory, as old, diesel-run fleets are replaced by electric alternatives.

In addition to targeting net zero carbon emissions, agencies are increasingly monitoring their impacts on biodiversity.

A growing number of infrastructure

agencies, including Transport for NSW (AU), Network Rail (UK), MTR (Hong Kong), and EirGrid Group (Ireland), have introduced dedicated biodiversity action plans, with an aim to improve the habitat quality within their corridors for wildlife and plants.

As corridors are often much wider than their movement channels, the potential is immense. Transport for NSW estimates that the state has approximately 1 million hectares of land designated as roadside reserve, of which 50% contain native vegetation.⁴

However, challenges persist in some regions. In England, National Highways experienced the loss of over half a million saplings along a 34 km stretch due to inadequate tree care and post-installation management. This underscores the importance of not only planning but also maintaining and managing these corridors to achieve their intended ecological benefits.⁵

The greatest opportunity for restoring biodiversity remains in the protection and creation of dedicated blue and green corridors.

Around the world, vital linear ecosystems have suffered degradation due to nearby human activities and are now in urgent need of restoration. Nine of the ten worst polluted large rivers in the world are in the Asia Pacific region, where 3.4 billion people could be residing in water-stressed areas by 2050.⁶

The fragmentation of habitats has had similarly destructive effects, making it imperative to prioritise connecting isolated patches.

In addition to restoring natural corridors, the greening of vacant or underutilised land can play an important role in establishing ‘stepping stones’ for birds and pollinators travelling through urban environments.

Sustainable by design

From an ecological perspective, the most sustainable transport and utility corridors are the ones we choose not to build.

When new construction is inevitable, creating fewer, larger corridors might be better than many medium-sized ones.⁷

The ecological impact of road and rail may be mitigated by letting grassland verges grow and implementing wildlife crossings.

In many cases, simply adding users, uses, or functions in a thoughtful manner can help to improve the sustainability of the corridor. Additionally, sustainability has to be safeguarded in the consideration and negotiation of future demands.

1. International Energy Agency (n.d.)
2. Carrington (2022)
3. National Highways (2021) (UK)

4. Transport for NSW (n.d.)
5. Haugh (2023)
6. Osti (2020)
7. See for example van Schalkwyk et al. (2020) and Rhodes et al. (2014)

Community is an important focus area in corridor design – and the scope is rapidly expanding.

“An important metric to measure the success of the corridor will be whether the Aboriginal community feel any sense of belonging to the landscape and connection to Country.”

Stakeholder interview quote (anonymised)

Corridors can play an important role in community development, namely by facilitating access to places, amenities, and resources.

Just as plants and wildlife rely on the circulation of natural resources and nutrients in riparian systems, the social and economic life of people largely depends on the circulation of human and capital resources in global transport systems.

One example of this can be seen in the United States, where the construction of the transcontinental railroad in the 19th century played a significant role in the development of the western region of the country.¹

Similarly, the construction of highways and interstates in the mid-20th century facilitated suburbanisation and the growth of many American cities.²

In developing countries, investment in transport infrastructure, such as roads and bridges, has been shown to promote economic growth,

increase access to services, and reduce poverty.³

Corridors can positively impact communities by:

- Supplying essential goods, resources, and nutrients
- Increasing access to economic and social opportunity
- Providing aesthetic and cultural benefit

Conversely, corridors may also inhibit communities by barring access to essential services or destroying existing habitats. One example of this is the upgrade of the Great Western Highway in New South Wales, which may impact up to 29 Aboriginal sites and important traditional lands.⁴

In 20th century USA, linear infrastructure was sometimes weaponised as a tool to enforce racism and class divides, creating socio-spatial scars that widely persist to this day.⁵ Understanding the historical context is essential

for developing more equitable and inclusive approaches to modern infrastructure.

Corridors can negatively impact communities by:

- Isolating, segregating, and fragmenting habitats/ neighbourhoods
- Disrupting natural ecological processes
- Facilitating poaching and other forms of exploitation

Often, both the positive and negative community impacts increase with the scale and capacity of the corridor, creating inherent tensions between achieving regional ‘gains’ and mitigating local ‘pains’. This challenge is exacerbated when the distinction between nodes (a place to stay) and channels (a place to move) is unclear.

It is rarely possible for linear infrastructure to meet the needs of all communities equally.

1. Lee (2022)
2. Herzog (2021)
3. Whittle (2009)

4. Gregory (2022)
5. Evans (2021)
6. Calder (2016)



Hassell case study: Cross River Rail is a new 10.2 km line incorporating 5.9 km of twin tunnels under the Brisbane River and city centre. Across both the client and design side, a focused, committed team has collaborated to make the project a model of accessible transport.

In, fact, all across the world, there are examples of large-scale infrastructure projects bringing significant benefits to some users while negatively impacting others.

The construction of a new high-speed railway in the UK (High Speed 2) has, for example, both been criticised for bypassing key towns⁶ and celebrated for cutting journey times.⁷ Additionally, the project has been criticised for its destruction of natural habitats.

Hence, when companies such as Queensland Rail (AU) aspire to “connect communities through a modern, world-class rail service,” or the San Francisco Public Utilities Commission (USA) aims to deliver water, power, and sewer services that encompass “environmental and community interests,” or when the Beijing MTR Corporation Limited strives to “promote community development,” it raises an important question: which community will ultimately take precedence?

7. Nottinghamshire County Council. (n.d.)
8. Bull (2013)
9. Tiegges et al. (2020)

The involvement of all stakeholders in these discussions – across ages, genders, abilities, and cultures – is of course paramount.

Meanwhile, the community benefit of well-maintained green and blue infrastructure remain widely undisputed.

Communities residing in close proximity to these natural spaces typically experience enhanced physical and mental well-being. For instance, in Scotland, a study demonstrated a remarkable social return on investment of 1:7 for a newly established cycleway in Motherwell.⁸ Additionally, another study found substantial reductions in the mortality rates among individuals residing near canals that had undergone significant regeneration efforts.⁹

Community by design

Accessibility is key to unlocking community benefits from linear infrastructure.

Smaller corridors organised in high-density networks are often more accessible at the local scale, while larger corridors in low-density networks can increase accessibility at a regional scale. By implementing crossings for people and wildlife, detrimental barrier effects may be reduced.

Corridors that are designed with a high habitat quality are often better integrated with the local community than those that only act as conduits.

Community consultation should be embedded as part of the design process from start to finish.

A HIGH STAKES GAME OF TRADE-OFFS

Corridors often achieve one objective at the expense of another.

It is, for example, very difficult to create a safe and efficient conduit for movement at the same time as a thriving habitat for communities. Likewise, it is near impossible to achieve connectivity at a regional scale without some degree of local severance – especially if financial limitations are in place.

When trade-offs are negotiated, three rules stand out:

- 1**
Even the best design in the world cannot meet all the world's objectives.
- 2**
When economic objectives outweigh social and environmental concerns, all are left at a disadvantage.
- 3**
Not all objectives are created equal or affect everyone the same.

“I think we need to say more clearly that some things are more important to integrate than others.”

David Tickle, Urban Design Sector Lead, Hassell

“We always need to be mindful that interventions to increase corridor efficiency at one spatial scale inevitably impact connectivity at other spatial scales.”

Martin Wedderburn, Wedderburn Transport Planning

“The opportunity to analyse complex trade-offs builds stronger cases for bolder projects. Our data models and analysis engine enables us to compute information about different scenarios, fast.”

Gala Camacho, Data Scientist, Diagonal Works

“Project KPIs typically focus on the primary axis of the corridor. Good design achieves these, whilst simultaneously tackling the challenges of the perpendicular axis. In achieving a balanced response to both axes, issues of scale, safety, severance, community, and equity can be positively addressed.”

Martin Knight, Managing Director, Knight Architects

“We have many singular bridges designed to stand up for a hundred years, but not to cater for a century of changing needs.”

Gareth Collins, Director, Urban Design, Roads and Waterways, Transport for NSW



How can shared goals across different linear infrastructure sectors lead to collective initiatives for change?

SHARED CHALLENGES

“A road department might only be allowed to acquire land to build a road, not to, for example, build a bike lane. The legislation becomes restrictive to thinking more unilaterally.”

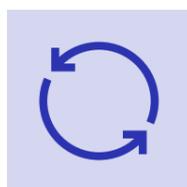
Stakeholder interview quote (anonymised)

SHARED OPPORTUNITIES



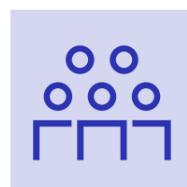
1 Creating safe corridors

- Use innovative technologies like digital fences and advanced sensors to increase safety without relying solely on physical barriers.
- Lower speed limits and reduce vehicle sizes in transport corridors to reduce the risk of fatal collisions.
- Consider multiple perspectives, including wildlife preservation and community impact, for comprehensive safety assessment.
- Engage stakeholders to align the corridor with local needs and foster a sense of responsibility for its safety.
- Raise or bury fast-moving, frequent, and heavy transport channels to create space for habitat functions, enhancing safety and preserving the environment.



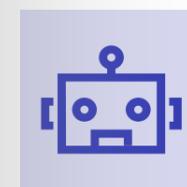
2 Running sustainably

- Monitor carbon emissions from construction, maintenance, operations, and use to identify areas for improvement and implement eco-friendly practices.
- Develop a biodiversity strategy to enhance the line-side estate's ecological balance through native plantings, wildlife corridors, and sustainable land management.
- Reduce dependencies on long-distance transport and utility corridors by sourcing materials locally and utilising renewable energy sources.
- Embrace circular economy principles to reduce waste generation and promote resource efficiency through recycling and upcycling.
- Develop resilience plans to address climate change impacts and ensure the corridor's preparedness for floods and other extreme weather events.



3 Benefitting communities

- Prioritise increased access to, and permeability of, the corridor, ensuring seamless integration with human, wildlife, and plant communities.
- Conduct comprehensive mapping of community impacts to evaluate both positive and negative consequences; trade-offs should be addressed fairly and transparently.
- Enhance the habitat quality of the corridor, particularly in densely populated communities, by using layering techniques.
- Involve community stakeholders to understand their unique requirements and foster a sense of ownership.
- Adopt a future-proof approach to account for changing community needs, demographics, and ecologies over time.



1 Mindless metrics

Metrics often play a key role in determining the effectiveness of linear infrastructure agencies and their assets, yet they often fall short in capturing holistic impacts.

Standard metrics tend to focus on easily quantifiable aspects such as safety based on collision data and efficiency measured by travel times. However, more comprehensive metrics should include qualitative insights like safety perception and travel experience.

Without these qualitative insights, a siloed mindset prevails, favouring narrow goals over a more well-rounded approach.

Digital tools may increasingly play a role in negotiating trade-offs, particularly between quantitative data points. To investigate this potential, we collaborated with Diagonal Works on a case study, which can be found in the appendix.



2 Decision inertia

Across all sectors, agencies encounter the challenging task of prioritising initiatives.

While research and community engagement can provide valuable insight, the array of competing objectives often creates a complex landscape of interdependent choices with no definitive answers. Additionally, agencies may be impacted by short political cycles, which stand in the way of implementing long-term strategies set out to safeguard the future.

This reality often results in decision-making inertia, where agencies hesitate to take decisive action, thereby reinforcing the status quo of siloed corridor management.

Where bold decisions are made to break the status quo, it is usually on account of buy-in from the highest levels of organisations.



3 Restrictive regulations

The linear infrastructure sector is typically subject to stringent regulations, and many agencies will have statutory responsibilities to fulfil before considering additional users or uses.

Such regulatory constraints often confine agencies to narrow objectives, limiting their ability to adopt a more holistic approach. Agencies operating within these 'siloed by law' structures find it challenging to explore innovative solutions that could benefit communities and the environment.

In some administrations, this challenge has successfully been overcome by consolidating responsibility for multiple functions under one agency.

Alongside regulations, laws governing the acquisition of land is often a barrier to tackling fragmented linear landscapes.

QUIZ TIME

Can you match the mission statement

- 1 Our role is running a safe, reliable, and efficient [corridor], serving customers and communities.
- 2 We will have a sustainable, inclusive, safe, and accessible [sector] system, helping deliver a healthier, fairer, and more prosperous [country] for communities, businesses, and visitors.
- 3 Our purpose is to enable safe and efficient journeys.
- 4 We connect [city] through a safe, equitable, and sustainable [sector] system.
- 5 The [organisation] every day connects people safely, supports opportunities and creates sustainable living places.
- 6 Our three principles of safety, operational excellence, and enhancing customer experience drive everything we do.
- 7 We are committed to enhancing life and liveability for the greater [city] region.
- 8 Our strategy to deliver on our mission of providing safe, reliable, efficient and sustainable [service] solutions.
- 9 We aim to be an internationally recognised company that connects and grows communities with caring, innovative and sustainable services.
- 10 Our vision is to be at the heart of a clean, fair and affordable [sector] future.

to the corridor management agency?

- Department for Infrastructure Roads Northern Ireland
- San Francisco MTA
- MTR Hong Kong
- Transport for New South Wales Roads and Maritime Services
- National Grid, United Kingdom
- Con Edison, United States of America
- Gas Networks Ireland
- Melbourne Water
- Transport Scotland
- Network Rail, United Kingdom

ANSWER KEY

- 1: Network Rail, United Kingdom
- 2: Transport Scotland
- 3: Transport NSW, Roads and Maritime Services
- 4: San Francisco MTA
- 5: Department of Infrastructure Roads, Northern Ireland
- 6: Con Edison, United States of America
- 7: Melbourne Water
- 8: Gas Networks Ireland
- 9: MTR Hong Kong
- 10: National Grid, UK

DESTINATION

05

REDEFINING CORRIDORS

Hassell project image: Gold Coast City Strategy, Queensland, Australia
Visualisation by Hassell

REDEFINING LINEARITY

COMMON CHALLENGES

EVALUATE

What gets measured?

Corridors are traditionally measured by their ability to transport people, resources, and goods safely and efficiently.

The data collected and reported play a significant role in shaping our understanding of success, influencing how corridors are envisioned, planned, and financed.

By relying solely on simplistic metrics, we risk creating corridors that may excel in one aspect but fall short in others, leading to imbalanced outcomes. For example, when the focus narrows down to metrics like vehicle speeds alone, the resulting outcome tends to prioritise the needs of drivers while neglecting the diverse requirements of other users.

The siloed organisational structure of corridor agencies, coupled with the challenges involved in measuring and reporting on aspects such as accessibility, social equity, and ecological value, frequently contributes to the limitation of evaluation criteria.

“Only that which gets measured gets valued by the Treasury.”

Stakeholder interview quote (anonymised)

PLAN

Who owns the vision?

Traversing multiple jurisdictions, corridors are often assembled under a patchwork of ownership and regulatory structures.

This fragmentation is frequently reflected in the lack of a common vision and leadership approach, which can hinder effective coordination and long-term planning efforts. As a consequence, there is a risk of missed opportunities and inadequate foresight in addressing evolving needs.

Even when a single agency or company is responsible for managing the corridor, there is often a tendency to focus solely on its immediate function as a conduit. This narrow perspective limits the consideration of multifunctional uses that could enhance the corridor's value and optimise its potential.

An important aspect of corridor planning also involves protecting existing public rights-of-way and acquiring land to meet future connectivity demands.

“Each sector has its own development plan but there is no systemic thinking.”

Stakeholder interview quote (anonymised)

BUDGET

Where is the money?

The construction and maintenance of corridors usually present a significant capital expense, yet rarely produce an immediate or direct capital return.

This reality, paired with short-term financial outlooks and shrinking public budgets, has resulted in systemic underinvestment in large-scale infrastructure projects in many parts of the world. The costs are likely to be felt in the near future in the form of critical infrastructure failures and supply shortages.

Aware of the challenges that lie ahead, public authorities are increasingly appealing to the private sector for support, by instigating new public-private partnerships (PPP) and implementing developer levies.

Still, ring-fenced budgets remain a barrier to tackling corridors in their entirety. When funds are allocated exclusively to particular segments or components of infrastructure, it can lead to suboptimal outcomes for the system as a whole.

“The agency's remit is to fund rail and transport, not a linear park.”

Stakeholder interview quote (anonymised)

Corridors are notoriously difficult to plan, challenging to build, and costly to maintain. From measurement and visioning through budgeting and design to construction and maintenance, the status quo repeatedly compels us to think and act in one-dimensional terms.

DESIGN

What gets prioritised?

Designing corridors is always a matter of weighing up competing options and objectives.

One-dimensional corridors, which are prone to fail people, nature, and the planet, are usually the result of narrow design briefs produced in an information vacuum by a single entity.

Multifunctional corridors, on the other hand, stem from holistic briefs, which are based on input from a variety of sources, including community members, design specialists, and technical experts. The conscious omission of some functions and users/uses in a corridor can be as important as its inclusions. Being clear on where the corridor might fall short is also the first step towards implementing adequate mitigation measures.

Designing corridors to fulfil various distinct goals often necessitates the creation of customised technologies and innovative, context-specific solutions.

“There's a huge space for innovation in corridor design.”

Stakeholder interview quote (anonymised)

BUILD

How is it made?

The construction of linear infrastructure usually involves extended periods of disruption and the use of carbon-intensive materials.

Corridors are typically built by a project management entity with the involvement of one or more construction companies.

Projects are often highly complex and require specialised engineering and construction expertise. This complexity can lead to cost overruns and delays if not managed properly. Even without delays, construction programmes often span several years if not decades. The building of London's Crossrail, for example, required eight tunnel boring machines, worth £10 million each, working 24 hours a day, overseen by 20 people, for three years straight, to carve out 21 km of tube routes.¹

Without continued oversight, there is also a danger that initial visions are lost in translation between idea and implementation.

“At the implementation stage, the focus is just on engineering.”

Stakeholder interview quote (anonymised)

MAINTAIN

Who looks after it?

Corridor management practices are often shaped by a desire to reduce perceived risks and day-to-day maintenance costs.

Maintaining and managing linear infrastructure requires a range of activities, including regular inspections, repair works, asset management, budgeting and planning, and emergency response.

Many of the corridor's maintenance requirements will be set out in the design phase, which is why collaboration between designers and future operators is key. Integrated solutions can save significant downstream operational costs.

The remit of the management or maintenance company/agency usually determines the corridor's capacity to operate with multiple users, uses, or functions in mind. Siloed operators are more likely to view additional corridor features as a safety risk, insurance liability, or threat to operations.

“In our outdated maintenance budgets, tarmac appears cheaper.”

Stakeholder interview quote (anonymised)

1. Heathman & Woolaston-Webber (2017)

Healthy corridors are shaped through leadership, collaboration, and holistic value definitions.



SHARED SOLUTIONS

EVALUATE

Capture value beyond numerical data

By embracing a broader set of metrics, we can ensure that corridors are designed and managed to enhance not only transportation/utility efficiency but also the overall quality of life, environmental sustainability, and social inclusion. Digital tools may also increasingly be helpful in capturing and evaluating the performance of diverse corridors, especially as they become capable of handling more qualitative data.

Holistic evaluations of linear infrastructure projects are usually based on:

- Comprehensive evaluation criteria that combine qualitative and quantitative data.
- Extensive community engagement activities designed to determine local priorities.
- Courage on the part of decision-makers to value that which matters, even if it cannot be measured.

“We have to learn to combine data with lived experience.”

Stakeholder interview quote (anonymised)

PLAN

Align stakeholders around a common vision

It is crucial to foster collaboration among stakeholders across jurisdictions and encourage a shared vision for the corridor. This involves developing effective governance structures, establishing clear lines of communication, and promoting coordination to ensure that the corridor’s planning and development consider a wide range of factors, including social, environmental, and economic considerations.

When corridor projects successfully unlock cross-sector synergies, it is usually due to:

- Strong, empowered, long-term public sector leadership.
- Early-stage collaboration between stakeholders and continued engagement with communities.
- Shifting from ‘predict and provide’ to ‘vision and validate’ future planning models.

“Working in partnership can be challenging but it’s obviously necessary.”

Stakeholder interview quote (anonymised)

BUDGET

Make the case for investing in the future

Removing restrictions on fund allocations is the first step towards addressing the corridor system as a whole. It allows for a more integrated and coordinated approach, enabling planners and decision-makers to consider interdependencies, optimise resource allocation, and design solutions that provide maximum benefits across the entire infrastructure network.

When the business case for investing in more holistic corridor projects proves viable, it is often due to:

- The implementation of a long-term investment strategy that considers the sustained benefits and future-proofing of the project.
- Equal prioritisation of social, economic, and environmental returns.
- Fair and equitable capture and sharing of value between the public and private sectors.

“Governments need to invest in infrastructure that’s set for the future.”

Stakeholder interview quote (anonymised)

DESIGN

Invent new solutions to combine priorities

New approaches to designing linear infrastructure involve integrating nature-based design principles, utilising smart technologies for design development and innovation, and engaging stakeholders in collaborative design processes. Furthermore, designing with climate change and resilience in mind ensures infrastructure can withstand and adapt to evolving conditions.

Corridors that are effectively integrated to deliver multiple outcomes in tandem often emerge from a design process that:

- Incorporates comprehensive community engagement and co-creation activities.
- Combines diverse skill sets and perspectives within an integrated project team.
- Takes advantage of new technologies to develop innovative solutions that specifically address identified needs.

“If you put the road in the right place, it becomes part of the landscape.”

Stakeholder interview quote (anonymised)

BUILD

Connect strategy and implementation

The gap between strategy and implementation has to be bridged by the presence of consistent leadership throughout a project. Additionally, holistic success criteria should be embedded within construction contracts alongside financial and timeline requirements. It is important to have clear phases, including time for experimentation, trial, and error.

To ensure the successful implementation of a multifaceted corridor project, several key factors come into play, including:

- Securing buy-in across the entire leadership team and amongst project managers.
- Setting statutory design frameworks as a safeguard against value engineering.
- Implementing a phased construction programme that accounts for both short-term and long-term gains.

“You can’t do everything at once. It’s a multi-generational process.”

Stakeholder interview quote (anonymised)

MAINTAIN

Look after complex ecosystems

To foster a more holistic approach to corridor management and maintenance, a fundamental shift in mindset and organisational culture is required. This shift involves recognising the value of social and environmental outcomes. Additionally, the implementation of smart technologies and data-driven design allows for real-time monitoring, optimisation, and adaptive management of the infrastructure, improving efficiency, safety, and the user experience.

Corridors that are maintained as holistic, multi-faceted spaces typically result from:

- Multidisciplinary or multi-agency management groups.
- Effective coordination of budgets and investments across the entire corridor ecosystem.
- Integration of nature-based and integrated maintenance mechanisms at the design stage.

“We always aim to connect design, maintenance, and operations.”

Stakeholder interview quote (anonymised)

FROM LINEAR SPACES TO NETWORKED PLACES

Corridors that are designed as integrated linear spaces within a wider non-linear context have the potential to deliver economic benefits, enhance social connectivity, and reduce habitat fragmentation, simultaneously.

Moving towards this approach will require new motives, technologies, and value definitions, designed to cut across administrative, physical, cultural, and professional boundaries.

With this report, we have endeavoured to share insights, recommendations, and case studies that showcase the advantages of integrated corridor design. Our hope is that it will inspire policymakers, infrastructure agencies, and designers to always think beyond the linear space.

NEW APPROACH

1 NEW MOTIVES

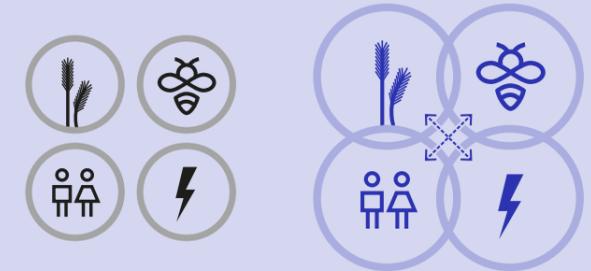
From isolated uses...

to overlapping uses.

Healthy corridors are designed to serve multiple functions for a variety of users and uses. New motives should be driven by a desire to create productive linear spaces for people, nature, and planet alike. This is the distinct difference between designing 'a route from A to B' and a 'linear transition between ecosystems'.

DO combine complimentary uses.

DON'T include everything and everyone just for the sake of it.



2 NEW TECHNOLOGIES

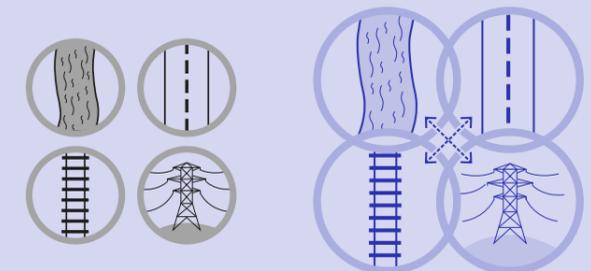
From siloed systems...

to integrated systems.

Healthy corridors are designed as integrated movement systems, driven by needs not by sectors. New technologies should be defined and developed based on the specific users, uses, and functions that the linear space is required to serve. This is the distinct difference between designing 'railway tracks for trains' and 'corridors for moving large volumes of people or goods at speed'.

DO develop new technology solutions to overcome silos.

DON'T invent new silos.



3 NEW VALUES

From simple metrics...

to holistic measures.

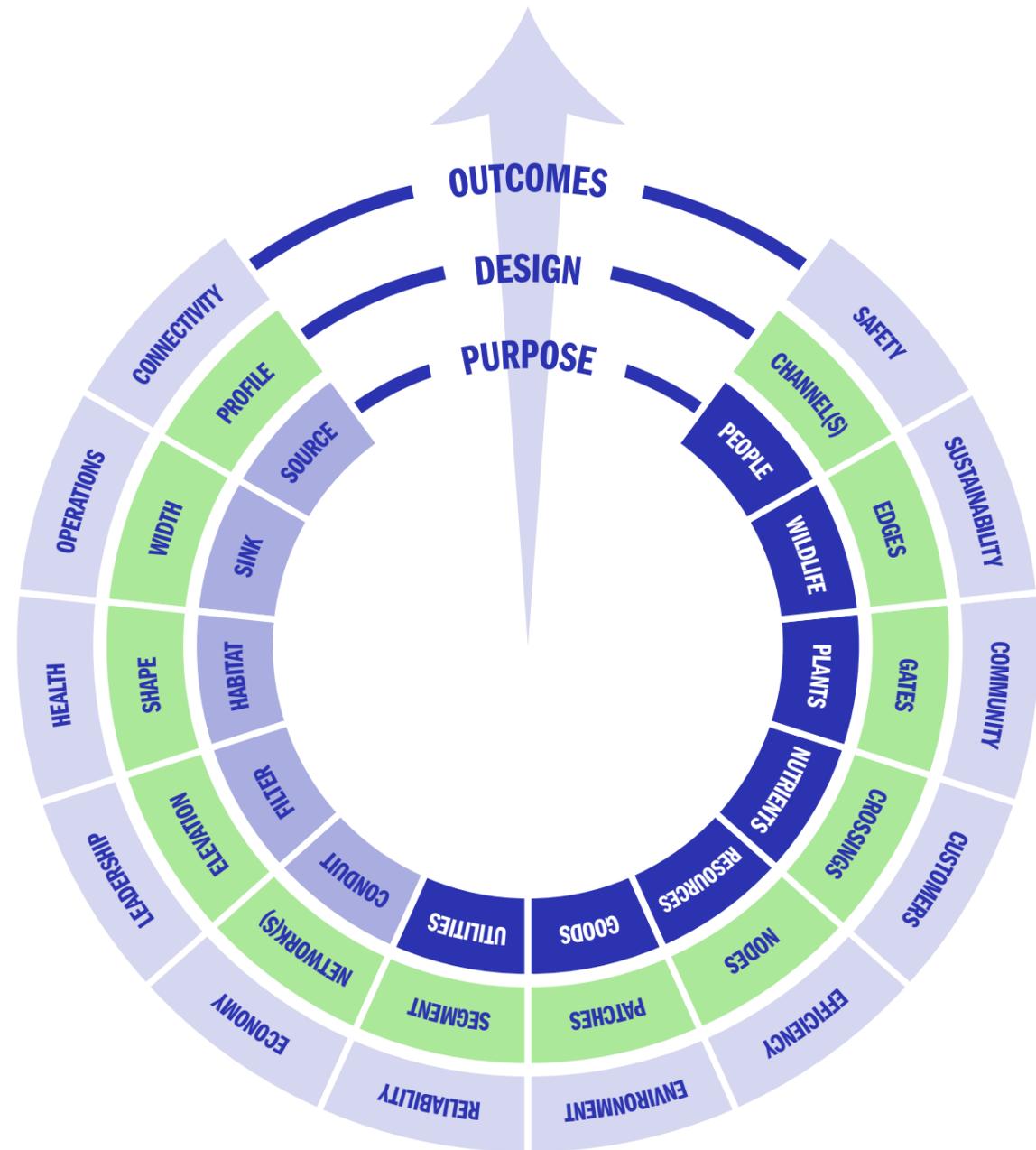
Healthy corridors are designed to perform against holistic evaluation criteria. New values should consider outcomes across social, environmental, and economic dimensions and prioritise long-term resilience. This is the a distinct difference between designing a 'safe road' and 'safeguarding the future of connectivity'.

DO set KPIs that reflect social, environmental, and economic needs.

DON'T forget to value that which cannot be measured.



TOOLKIT



Why does the corridor exist?
What is its purpose?

How does the corridor work?
What are its design qualities?

What does the corridor achieve?
What are its outcomes?

One of the recurring challenges in ‘non-linear’ corridor design is the prioritisation of conflicting uses, users, functions, and objectives. In the absence of a single universal design to meet all demands, we are always required to seek compromises, carefully weigh options against one another, and determine what we ultimately value most.

With the creation of a common taxonomy and associated workshop toolkit, we hope to help these conversations between diverse stakeholders on their way.

1 PURPOSE

The purpose of the corridor is its reason for existing; corridors can and should exist to serve more than one purpose.

Use the inner circle of the diagram to draw connections between all the corridor’s potential users and uses, and its prospective functions; consider all combinations.

- Define the desired combination of users, uses, and functions - combinations may vary over time.
- Identify and mitigate against users, uses, and functions that may be in conflict with the corridor’s primary purpose.
- Identify and intensify secondary users, uses, and functions that may complement the corridor’s primary purpose.

2 DESIGN

The design of the corridor determines how the linear space works to serve its purpose, meet its objectives, and drive outcomes.

Use the second circle of the diagram to discuss the corridor’s typical design components outside the traditional language of linear infrastructure silos.

- Understand existing geometries and structures that may assist or constrain the corridor’s ability to meet its purpose.
- Create a design brief that considers the corridor in its entirety and not merely as a channel acting as a conduit.
- Develop new geometries and structures to shape the corridor in accordance with its purpose.

3 OUTCOMES

The purpose and design of the corridor combine to produce a range of outcomes; desired outcomes become design objectives.

Use the third circle of the diagram as a point of inspiration to define the project’s desired outcomes; define each outcome in relation to the inner circle of users, uses, and functions.

- Outline a range of desired outcomes, considering different time frames.
- Examine how the outcomes may be achieved for each of the corridor’s users, uses, and functions.
- Identify and mitigate against potential negative outcomes which may arise from the corridor’s primary purpose.

INSPIRATION FROM THE HASSELL PORTFOLIO

**COLMA CREEK ADAPTATION PLANNING, SAN FRANCISCO
PACIFIC HIGHWAY UPGRADE, NEW SOUTH WALES
RIVER TORRENS LINEAR PARK, ADELAIDE
LEVEL CROSSING REMOVAL PROJECT, MELBOURNE
LONGGANG RIVER BLUEWAY, SHENZHEN
METRO NORTH WEST, SYDNEY**

“The purpose of public works must be to ensure social integration, meeting future needs, and encouraging civiness. That’s why I think ‘infrastructure’ is the wrong word. It’s too simple when what we are really talking about is enabling people to live rich, rounded, fulfilling lives.”

Ross de la Motte, Principal, Hassell



Hassell project image: Level Crossing Removal Project,
Cherry Street, Melbourne, Australia
Photography by Sarah Pannell

COLMA CREEK ADAPTATION PLANNING, SAN FRANCISCO



Imagining a healthy and resilient future for the Colma Creek urban waterway through creative engagement with experts and communities of all ages.

-  **INCREASING ACCESSIBILITY**
-  **FLOOD RISK MITIGATION**
-  **COMMUNITY CO-CREATION**

LENGTH 3.2 KM YEAR 2020-ONGOING STATUS IN CONSULTATION
CLIENT BAY AREA REGIONAL COLLABORATIVE, SAN MATEO COUNTY, CITY OF SOUTH SAN FRANCISCO
COLLABORATION CHS CONSULTING, THE CIVIC EDGE CONSULTING, E2 DESIGN LAB, LOTUS WATER

As a small natural waterway, Colma Creek flows from San Bruno Mountains through San Mateo County to San Francisco Bay. However, together with the urban development of the region, the creek has also lost many of its natural properties. It is today dominated by concrete flood control walls, and it is therefore mostly inaccessible to the public and ineffective as a habitat for wildlife and plants. Moreover, the creek has become a barrier between the shoreline and local communities, and no longer has the capacity to protect either from flooding.

In 2017, the Resilient by Design: Bay Area Challenge was launched

with an aim to inspire new, creative solutions to tackle the region's threat of sea-level rise and flooding brought on by climate change. Hassell led a project team that was successfully selected to carry on work, resulting in the Colma Creek Adaptation Planning Report.

Dubbed the "Colma Creek Connector" project, the study explores a range of design options for restoring natural habitats and increasing public access along and across the corridor. These are presented as a toolkit and resource to inspire localised action.

Local communities are central to this new vision for the city's waterways.

The project evolved alongside a series of public engagement events, designed to build awareness of the creek and its future potential. The team also created a children's book, distilling complex ideas about ecology, equity, and resilience in a way that might better engage the next generation of waterway custodians. The book was released in four languages, reflecting the region's diverse communities.



Image: Colma Creek as it is today

PORTFOLIO

PACIFIC HIGHWAY UPGRADE, NEW SOUTH WALES



Hassell has been involved in 18 landscape architecture and urban design projects shaping part of the award-winning Pacific Highway upgrade over two decades.

-  USER EXPERIENCE
-  SAFE TRAVEL
-  ENVIRONMENTAL MITIGATION

TOTAL LENGTH OF HASSELL INVOLVEMENT 400 KM YEAR SINCE 2003 STATUS COMPLETED
 CLIENT VARIES (INCLUDING BAULDERSTONE HORNIBROOK / THIESS / CPB CONTRACTORS)
 COLLABORATION VARIES (INCLUDING SMEC / HYDER / DOUGLAS PARTNERS / AURECON / THIESS)

The Pacific Highway upgrade project was launched in 1996 with an aim to improve safety, connectivity, and efficiency along one of Australia’s busiest transport corridors.

Stretching over 660 kilometres from Sydney to Brisbane, the upgrade set out to widen the existing highway, construct new sections, and enhance key intersections to accommodate a growing volume of traffic.

Over the past 20 years, Hassell’s landscape architecture and urban design teams have been involved in 18 projects forming part of the overall scheme. In every instance, our approach has been to shape the corridor into a more sustainable,

user-friendly, and visually appealing environment, fitting for the landscape and its surrounding human and ecological communities.

Working on a 10 km stretch through Nابیac (pictured), Hassell helped insure that key design issues, including vertical and horizontal alignment, connections between existing streets and the highway, and new bridges and overpass structures, were resolved based on sound landscape and urban design principles.

Between Oxley and Kundabung, the upgrade set out to create a memorable gateway to Port Macquarie, as the road meanders

through coastal floodplains, forests, and pasture land.

Other projects have seen the integration of safe and inviting public spaces along the corridor, incorporating amenities such as rest areas, landscaping, and pedestrian and cyclist-friendly infrastructure.

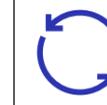
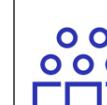
Since 2004, the holistic approach of this large-scale infrastructure project has been safeguarded by the Pacific Highway Urban Design Framework. Altogether, the upgrade has resulted in a 70% reduction in fatal crashes, 2.5 hours reduced travel time, and 9,000 hectares of native vegetation protected.¹

1. NSW Roads and Maritime Services (2023)

RIVER TORRENS LINEAR PARK, ADELAIDE



Between 1979 and 1997, the River Torrens linear park was transformed from an unsafe and unsightly drain into one of Adelaide’s most-loved destinations.

-  ECOLOGICAL RESTORATION
-  FLOOD RISK MITIGATION
-  SOCIAL BENEFIT

LENGTH 30 KM YEAR 1979–1997 STATUS COMPLETED
 CLIENT SOUTH AUSTRALIA WATER
 COLLABORATION LAND SYSTEMS

The River Torrens (Karrawirra Pari) is the most significant river of the Adelaide Plains, flowing from its source in the Adelaide Hills through suburbs, past the city centre, and into the sea at South Australia’s west coast.

With the urbanisation of Adelaide, the river suffered severe ecological degradation, causing poor water quality and increasing flood risks.

In order to tackle these challenges, the state-owned Engineering and Water Supply Department (South Australia Water) formed a partnership with twelve local councils and, in the 1970s, aspired to create Australia’s first linear park.

This collaboration was in itself a first, and has since been recognised as a case study in ‘green governance’.¹

In 1979, Hassell and Land Systems prepared a comprehensive management framework to guide the development of the scheme, passing the first milestone in what would become a decades-long shared journey.

The design set out to mitigate floods and manage stormwater, regenerate the river’s biodiversity, and bring new social and economic opportunities to local communities.

The area’s water quality was addressed by reinstating tributaries and establishing new wetlands.

Biodiversity was improved by eradicating invasive species in favour of indigenous plants. By re-establishing the dominant native tree canopy of River Red Gum (*Eucalyptus camaldulensis*), environments that had been fragmented by varied land uses were linked together again.

In order to increase the public utility of the corridor, the scheme also implemented new walking and cycling paths, public spaces, and recreational facilities.

40 years later, the River Torrens Linear Park has become one of Adelaide’s most-loved destinations.

1. Ibrahim et al. (2020)

PORTFOLIO

LEVEL CROSSING REMOVAL PROJECT, MELBOURNE



With an ambition to remove more than 100 dangerous level crossings across Melbourne, the LXR project has also created an opportunity for enhancing active travel conditions and accessibility.



IMPROVING
SAFETY



TRAVEL
RELIABILITY



HEALTHY
COMMUNITIES

LENGTH 12 KM YEAR 2017-ONGOING STATUS UNDER CONSTRUCTION
CLIENT LEVEL CROSSING REMOVAL AUTHORITY & WESTERN PROGRAM ALLIANCE
COLLABORATION VARIES (MCCONNELL DOWELL / ARUP / MOTT MACDONALD / DENTON CORKER MARSHALL)

The Level Crossing Removal (LXR) Authority was formed in 2015 to oversee the removal of 50 dangerous and congested level crossings across Melbourne. Since then, more crossings have been announced for removal, bringing the total number of sites to 110.

Hassell's involvement in the Level Crossing Removal Project started in 2015, when the practice together with CPB Contractors, Aurecon, and Arcadis, won the contract to deliver four projects: Furlong Road, Main Road, Blackburn Road, and Heatherdale Road. The level crossings were all removed by lowering the train lines below street

level within tight suburban contexts. The project included the design of new railway stations, access improvements, bus interchanges, cycle paths, pedestrian bridges, and new public spaces.

In 2017, Hassell became involved in the Cranbourne Line upgrade project, which involved 12 km of track upgrade and duplication along with several level crossing removals. In addition to developing a revegetation strategy for restoring habitat links, Hassell also collaborated with the University of Melbourne to implement a 'Woody Meadows' low-maintenance high-biodiversity planting system, which has since

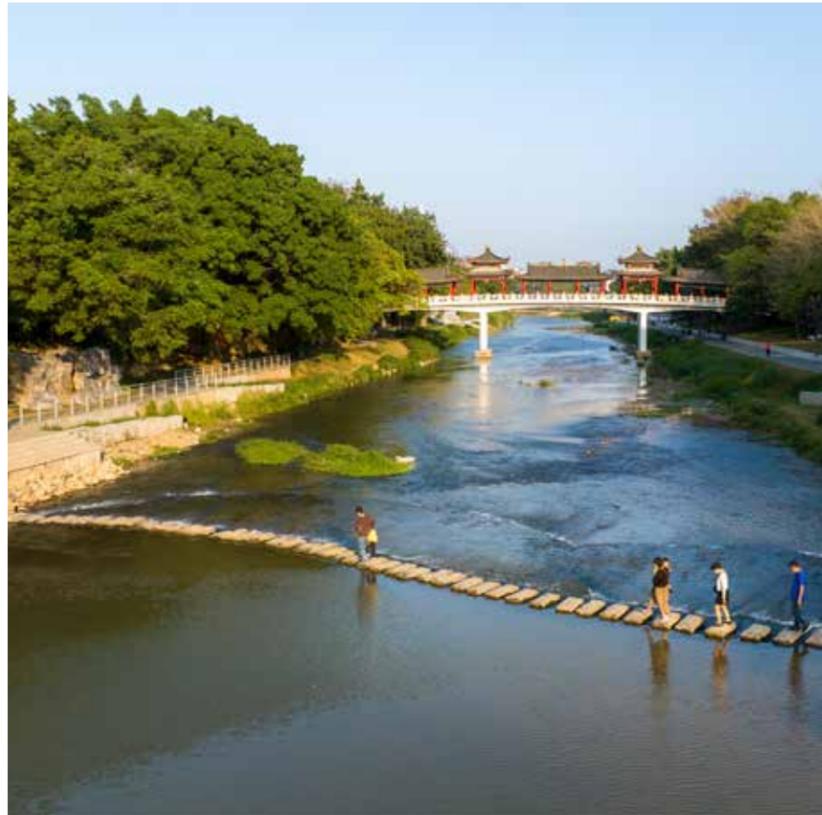
been adopted on other level crossing removal landscapes.

Most recently, Hassell have completed landscape designs for LXR projects at Cherry Street (pictured above), Ferguson Street, and Werribee Street (pictured overleaf).

At Werribee Street, the removal of the level crossing has resulted in significant travel improvements for 20,000 daily commuters, an increase in native vegetation, and a custom-built skatepark. The design also includes a space where children can play, and people can gather and learn the local Wadawurrung language.

PORTFOLIO

LONGGANG RIVER BLUEWAY, SHENZHEN



Balancing ecology, community, culture, and commerce, the restoration of the Longgang River has become an example of how to achieve great results through engagement and thoughtful compromise.

-  ECONOMIC OPPORTUNITY
-  ECOLOGICAL INTEGRATION
-  COMMUNITY PATHWAYS

LENGTH 24 KM YEAR ONGOING STATUS PILOT PHASE COMPLETE
 CLIENT WATER AUTHORITY OF SHENZHEN
 COLLABORATION UPDIS, E2DESIGN

Longgang River is a freshwater river stemming from Wutong Mountain, running southwest to the northeast across the central area of Longgang. Passing through Shenzhen, the river has witnessed both the positive and negative effects of economic development over many years.

Hassell won an international design competition organised by Shenzhen Water Authority to work on a 23.6 km section of the 1,000 km river system, as it passes through tech-centres, metropolitan areas, and historical precincts. When completed, the project will connect the waterfront with the surrounding urban areas and realise the vision of

an integrated waterway, balancing ecology, community needs, and commercial demands.

The final design looks to recover and improve the accumulation of sediments caused by flooding, protect eco-fragile banks, improve community and general public accessibility to the waterfront, establish better amenities to help people 'linger-longer', and build stronger connections between the Longgang River and adjacent urban developments.

In addition to integrating these varied functions into a single complex linear system, the project has also had to bring together 370

different landowners and countless communities around a single vision. Consequently, the final corridor design exemplifies both the power of engagement and the importance of compromise.

The first phase of the project, a 4 km stretch, was completed in 2023. Since then, a diverse mix of communities have been observed reclaiming the space along the waterfront as a commuter route, cultural anchor, and recreational destination. The design also serves an important function for the entire watershed, by filtering runoff water before it is discharged to the area's primary waterways.

METRO NORTH WEST, SYDNEY



As Australia's first fully-automated, fully-accessible rail system, the Metro North West project was designed to connect communities and bring new economic opportunities to Sydney's northern suburbs.

-  CONNECTING COMMUNITIES
-  ECONOMIC DEVELOPMENT
-  COMMUNITY DEVELOPMENT

LENGTH 36 KM YEAR 2019 STATUS COMPLETED
 CLIENT CPB JOHN HOLLAND AS PART OF NORTHWEST RAPID TRANSIT
 COLLABORATION TURPIN CRAWFORD STUDIO, MCGREGOR WESTLAKE ARCHITECTURE

The Metro North West line is a 36km corridor with 13 stations, running through the north-western suburbs of Sydney from Tallawong to Chatsworth. The project includes two 15-kilometre tunnels serving the route from Bella Vista to Epping.

As Australia's first fully-automated metro-rail system, the line is expected to carry up to 40,000 passengers per hour at peak times.

Hassell was responsible for designing 8 of the 13 stations along this crucial transport corridor, including Castle Hill, Hills Showground, Norwest, Bella Vista, Kellyville, Cherrybrook, Tallawong and Rouse Hill, as well as upgrading

the remaining 5 existing stations along the route.

Each station was designed to be an integral part of the local community, with a focus on accessibility, sustainability, and user experience.

The designs incorporate local materials, such as sandstone and timber, and feature several public art installations. Though each station is visually different, they can all be defined by their recognisable station canopies.

The Metro North West project is part of a wider government initiative to promote transport-oriented development across the metropolitan area.

Three station areas (Bella Vista, Kellyville, and Showground) have already been re-zoned, unlocking the construction of up to 13,400 new homes over the next 20 years.

Accordingly, all stations along the new line have been designed as destinations in their own right, with the integration of public plazas, parks, and footpaths, drawing people to stay as well as travel.

FURTHER INSPIRATION

THE HIGH LINE, NEW YORK

Transforming a disused elevated railway line into a much-loved walkway

CHEONGGYECHEON, SEOUL

Rediscovering a blue corridor buried under a busy highway

GREENING THE PIPELINE, MELBOURNE

Transforming a heritage-listed pipeline reserve into a new parkland

ECODUCTO RIO DE LA PIEDAD, MEXICO

Adding a water-purifying linear park to a main road built over an encased river

THE HEART GARDENING PROJECT, MELBOURNE

Communities greening streets to create new pollinator corridors

LOW LINE, LONDON

Creating a walking and retail destination alongside repurposed rail arches

RAILS TO TRAILS, USA

Transforming existing disused railways into adventure trails

MAGWAY, UK

Repurposing old utility pipes for the sustainable transportation of goods

SMART CANAL, GLASGOW

Using 21st century technology to manage 19th century waterways

THE BENTWAY, TORONTO

Creating a public space underneath an expressway for community and art

THE HIGH LINE, NEW YORK

Transforming a disused elevated railway line into a much-loved walkway



Designed by James Corner Field Operations, Diller Scofidio + Renfro, Piet Oudolf

LENGTH 2.3 KM WIDTH 10–20 M
CONSTRUCTION COST (2006-2009) US\$152.3 MILLION
MANAGEMENT FRIENDS OF THE HIGH LINE
OWNERSHIP CITY OF NEW YORK

The High Line is a 2.3 kilometre-long elevated park built on a former railway line on Manhattan's West Side. It was opened in 2009, and has since become one of New York's most popular attractions.

The High Line was originally part of a freight rail system that served the Meatpacking District and other industrial areas in the city. Later, the railway line fell into disuse and disrepair. It was scheduled for demolition in the 1990s.

Local residents and activists formed the Friends of the High Line to transform the structure into a public park. The High Line now serves as a green corridor connecting the Meatpacking District to Hudson Yards. It features native plants, public art installations, and seating areas, providing a respite from the city's hustle and bustle. It has also spurred economic development in the surrounding areas, attracting new businesses, restaurants, parks and residential buildings.

- From New York City's investment of \$115 million USD, the High Line stimulated over \$2 billion USD in urban development and created 12,000 new jobs by 2011.¹
- Annual operating, maintenance, and programming costs are nearly 100% covered by donations.²
- With over 110,000 plants within 500 vascular plant species,³ the High Line is incredibly biologically diverse.
- 750 trees sequester over 1.3 tons of atmospheric carbon annually, while canopies intercept over 24,340 gallons of stormwater.⁴
- Friends of the High Line hosts more than 450 public programs and activities, aimed at supporting the diverse communities that surround the High Line and facilitating inclusive gatherings for all visitors.⁵

1. McGeehan (2011) quoting NYC Mayor Michael Bloomberg
2. Friends of the High Line (n.d.) (1)
3. Stalter et al. (2021)
4. Plunz & Moskalenko (2017)
5. Friends of the High Line (n.d.) (2)

CHEONGGYECHEON, SEOUL

Rediscovering a blue corridor buried under a busy highway



Designed by SeoAhn Total Landscape

LENGTH 5.8 KM WIDTH 20–116 M
CONSTRUCTION COST (2003-2005) US\$380 MILLION
MANAGEMENT/OWNERSHIP SEOUL METROPOLITAN FACILITIES
MANAGEMENT CORPORATION / SEOUL METROPOLITAN GOVERNMENT

By demolishing an elevated freeway carrying over 170,000 vehicles daily, the City of Seoul was able to reclaim and restore the channel of the historic Cheonggyecheon Stream for ecological and social benefit.

The Cheonggyecheon Restoration Project was delivered through a management structure that involved public agencies, private groups and partnerships, citizen associations and unions, and designers and engineers.

The project involved removing the highway and uncovering the stream, which was then cleaned and restored. The restoration also included the creation of a pedestrian-friendly promenade, public art installations, and ecological features such as wetlands and fish habitats. The restored stream has since become a popular destination for locals and tourists alike, contributing to the revitalisation of the surrounding neighbourhoods.

- It is estimated that the corridor attracts an average of 64,000 visitors daily (2009 figures), with foreign visitors contributing US\$1.9 million to the Seoul economy.¹
- Properties located within 50 meters of the restoration project increased at 30-50% – twice the rate of comparable areas across the city.²
- The corridor increased overall biodiversity by 639% between the pre-restoration work in 2003 and the end of 2008.³
- Almost 4,000 meetings were held with residents and a Wall of Hope programme was developed to encourage civic involvement.⁴
- The restoration has lowered the risk of respiratory diseases for local residents by reducing small-particle air pollution by 35% from 74 to 48 micrograms per cubic meter.⁵

1. Robinson & Myvonnwyn Hopton (2011)
2. Ibid.
3. Ibid.
4. Global Designing Cities Initiative (n.d.)
5. Revkin (2009)

GREENING THE PIPELINE, MELBOURNE

Transforming a heritage-listed pipeline reserve into a new parkland



Image: Wyndham City Council

LENGTH 27 KM WIDTH 40 M
FUNDING TO DATE AU\$ 15+ MILLION
COLLABORATIVE MANAGEMENT DEPARTMENT OF TRANSPORT & PLANNING, MELBOURNE WATER, WYNDHAM CITY COUNCIL

'Greening the Pipeline' sets out to transform a 27 km heritage-listed Main Outfall Sewer (MOS) pipeline in Melbourne's Western suburbs into public space and parkland. Through adaptive reuse as a Green Infrastructure asset, the MOS is given a new life, providing ecosystem services with multiple environmental and social benefits. A 22-megalitre stormwater harvesting system will collect water from the urban catchment, treat it in reed beds, store it within the MOS, and reuse it to irrigate open green spaces, supporting tree canopy growth and urban cooling. In addition to improving habitat for local wildlife, the scheme also includes new paths, community gardens, and public art. The project is being managed by a collaborative alliance between Wyndham City Council, Melbourne Water, Greater Western Water, the Department of Environment, Energy and Climate Action, the Department of Transport and Planning, and Traditional Owners, supported by Greening the West.

- The project forms part of the Victorian Government's Suburban Parks Program, which will invest more than \$315 million to create more than 6,500 ha of new and upgraded parks and trails across Melbourne's growing outer suburbs.¹
- To effectively manage design, delivery, and planning of the project, the reserve has been split into 9 development zones.
- A pilot park project of a 100 m section at Williams Landing was completed in April 2017. Partners are currently implementing the 3.8 km Zone 5 masterplan.²
- Surveys of the Williams Landing Pilot Park show 105% increase in visitation.³
- Since 2018, over 60,000 trees have been planted through the Greening the West '1 Million Trees' and the 'Trees for a Cooler Greener West' programs.⁴

1. Department of Environment, Land, Water and Planning (2023)
 2. Greening the West (n.d.)
 3. Cooperative Research Centre for Water Sensitive Cities (2018)
 4. Wyndham City Council, personal communication, September 01, 2023

ECODUCTO RIO DE LA PIEDAD, MEXICO

Adding a water-purifying linear park to a main road built over an encased river



Image: Regina Ferrel and Fernando Camacho

LENGTH 1.6 KM AREA 8,000 M²
CONSTRUCTION COST (2017) US\$ 4.5 MILLION
MANAGEMENT/OWNERSHIP AGENCIA DE GESTIÓN URBANA (CITY OF MEXICO) & CUATRO AL CUBO

The Ecoducto is a raised greenway and water purification system that spans 1.6 km along and above the Viaducto Miguel Alemán freeway.

The linear space was originally a river (Rio la Piedad), which had been encased beneath the six-lane freeway and made inaccessible to the surrounding community.

Through citizen activism, the potential of this corridor was raised, and in 2018 the Ecoducto park opened.

The linear park has four types of wetlands and eight biodigesters, which remove the main pollutants from the atmosphere: carbonaceous matter, pathogenic microorganisms, nutrients, suspended solids, and heavy metals.

The project was undertaken by the Urban Management Agency in partnership with the citizen-led environmental organisation Cuatro al Cubo.

- The Ecoducto Rio de la Piedad includes 4,800 m² of vegetation, which contribute to reducing traffic noise by up to 10 decibel.¹
- The linear park captures 50 tons of carbon a year and reclaims 30,000 litres of water every day.²
- Birdlife has increased from 4 to 17 species, interacting with 13 types of water plants and 47 species of insects.³
- The park gives back about US\$4 million per year in ecological services, such as water filtering, CO₂ capture, smog reduction, and ambient temperature regulation, and social services, such as public spaces, greenery, and playgrounds.⁴

1. García et al. (2020)
 2. Chambard et al. (2015)
 3. Grabinsky (2019)
 4. Ibid.

THE HEART GARDENING PROJECT, MEL

Communities greening streets to create new pollinator corridors



Image: Emma Cutting

LENGTH (MELBOURNE POLLINATOR CORRIDOR) 8 KM
CROWD & LOCAL FUNDING AU\$ 220,000+
LAND MANAGEMENT LOCAL COUNCILS / PRIVATE LAND OWNERS
DESIGN & MAINTENANCE COMMUNITY-LED

The Heart Gardening Project (THGP) is a charity founded by Emma Cutting with a mission to connect humans to humans, humans to nature, and nature to nature through street gardening.

Based in Melbourne, Australia, THGP is transforming barren, under-utilised public, urban land into beautiful gardens for people, insects, and pollinators to enjoy. The organisation is currently focused on the Melbourne Pollinator Corridor (MPC) which will be Australia's first ecology-driven, community-led wildlife corridor linking two diverse green patches that run along the Birrarung, Westgate Park and the Royal Botanic Gardens. In both its approach and scope, the MPC is challenging how public realm is designed, used, and maintained.

- THGP has made significant contributions to enhancing biodiversity in Melbourne, including the establishment of 80+ street gardens, collaboration with 60+ multi-disciplinary specialists, and instrumental efforts in modifying local legislation to support the practice of street gardening by residents.¹
- The MPC aims to create 200 indigenous-focused pollinator gardens by the end of 2024. 23 gardens are already completed and another 40 are to be planted by the end of 2023.²
- So far, over 1,500 m² of barren public land have become gardens filled with critters and beauty.³

"Our streets have so much wasted space. Street gardening brings out the community, and the pollinators follow."

Emma Cutting, Founder, The Heart Gardening Project

1. The Heart Gardening Project, personal communication, July 25, 2023
 2. The Heart Gardening Project (n.d.)
 3. The Heart Gardening Project, personal communication, July 25, 2023

LOW LINE, LONDON

Creating a walking and retail destination alongside repurposed rail arches



Image: Rumi Bose

LENGTH 6 KM AREA 260,000 M²
FUNDING £2 MILLION
OWNERSHIP LOCAL COUNCILS / PRIVATE LAND OWNERS
MANAGEMENT COMMUNITY-LED

The Low Line in Southwark, London, is a major urban greening and regeneration initiative that sets out to repurpose a 150 year old disused railway viaduct.

By celebrating the heritage of the railway arches and repurposing them for new uses, the Low Line is transforming the urban landscape and providing new opportunities for economic prosperity, outdoor recreation, cultural engagement, and social connection, while providing concurrent ecological benefits.

The concept was developed by a group of initial partners, including Southwark resident David Stephens, Better Bankside, Blue Bermondsey, Borough Market, Team London Bridge, The Arch Company, and Southwark Council, who are steering the initial scoping, planning, and communication of the project. The project has around £1m in funding from the project partners and a further £1m from Mayor of London Sadiq Khan's Good Growth Fund.

- 390 arches are home to 250 businesses across 110,000 m² of space.¹
- The Low Line provides capacity for around £4.3 million business rates generation per annum.²
- The urban transformation of the railway arches also aims to deliver 50,000 m² of biodiverse roofs, 500 new trees, 30 sustainable drainage systems/rain gardens, 10,000 plants, 100 new wildlife habitats, and 1,000 m² of wildflower meadows.³

1. Allies and Morrisson Urban Practitioners & Hatch Regeneris (2019)
 2. Ibid.
 3. The Low Line (n.d.)

RAILS TO TRAILS, USA Transforming existing disused railways into adventure trails



Image: Adobe Stock

LENGTH >40,000 KM WIDTH 3–10 M
MAINTENANCE COSTS US\$50–2,000 / TRAIL MILE / YEAR
MANAGEMENT RAILS-TO-TRAILS CONSERVANCY
OWNERSHIP UTILITY COMPANY / PUBLIC ENTITY

The Rails-to-Trails Conservancy (RTC) is a non-profit organisation based in the United States that works to transform former railroad corridors into multi-use trails for non-motorised transportation and recreation. The organisation was founded in 1986, and has been instrumental in creating hundreds of trails across the country.

The RTC works with local governments, landowners, and other stakeholders to acquire and convert abandoned rail corridors into trails for walking, running, cycling, and other non-motorized activities. The organisation also provides technical assistance and resources to local communities to help them develop and maintain their own rail-trails.

The rail-trail network created by the RTC has become a valuable asset for communities across the United States, providing safe and accessible routes for active transportation and recreation.

- It is estimated that the creation of a 6,000 km cross-country multi-use trail (the proposed Great American Rail-Trail®) could generate more than \$229.4 million in visitor spending, \$104 million in labour income and \$22.8 million in new tax revenue.¹
- Across the US, 40% of rail trails also function as utility corridors. The Town of Lloyd in the Hudson Valley received \$400,000 to allow fibre optic cable to be laid under its five-mile rail-trail.²
- Since 1983, the RTC have been involved in more than 60 legal cases to lay the groundwork for the national trails movement.³
- Trails have also been shown to bring sustainable tourism benefits.⁴

1. Headwaters Economics (2022)
2. New York Parks & Conservation Association (n.d.)
3. Kapp (2020)
4. Reis & Jellum (2012)

MAGWAY, UNITED KINGDOM Repurposing old utility pipes for the sustainable transportation of goods



Image: Magway Limited

LENGTH 850 KM PROPOSED WIDTH 90+ CM DIAMETER PIPES
INSTALLATION COSTS ESTIMATED £1.5 MILLION / KM PIPE
MANAGEMENT MAGWAY LTD.
OWNERSHIP UTILITY COMPANIES

Magway Ltd. was founded by Phill Davies and Rupert Cruise in 2017 with a mission to create an all-electric, zero-emissions, low-footprint, high-capacity delivery system. The concept uses linear motors to propel pods containing goods along tracks installed in disused utility pipelines.

According to Magway, the system can transport the equivalent of 3,000 articulated lorry loads per day per pipe at 54km/hour.

Magway raised £1.58 million through crowdfunding in 2019 and was awarded a further £1.9 million from the UK Government in 2020. The same year, they completed the first operational demonstrator in a Wembley test facility.

- In 2022, vans accounted for 16% and HGVs accounted for 19% of the UK's domestic transport emissions.¹
- The Magway system has the potential to take 90% of delivery vehicles for online retail off the roads, connecting urban areas, shipping terminals, distribution centres, and airports.²
- Magway's high-capacity delivery system is able to dispatch an HGV worth of goods every thirty seconds and a single two-way system has a capacity equivalent to 40,000 HGV journeys a week.³

“There is an enormous market for moving small things individually, and a great number of underground disused utility pipes.”

Huw Thomas, Development Director, Magway

1. Department for Transport (2022) (UK)
2. Magway Ltd. (2021)
3. Ibid.

INSPIRATION

SMART CANAL, GLASGOW Using 21st century technology to manage 19th century waterways



Image: Adobe Stock

LENGTH 30 KM WIDTH ~15M
COSTS/BUDGET £17 MILLION¹
DELIVERY METROPOLITAN GLASGOW STRATEGIC DRAINAGE SCHEME
(GLASGOW CITY COUNCIL, SCOTTISH CANALS, SCOTTISH WATER)

The North Glasgow Integrated Water Management System is an innovative example of re-imagined corridors, combining technology and sustainability to transform the city's waterways.

Equipped with sensors and data-driven infrastructure, the canal is capable of monitoring water quality, flow rates, and detecting any potential issues in real-time. The smart system optimises water usage, reducing wastage and conserving resources. The canal also integrates smart lighting and energy-efficient technologies, enhancing safety and reducing energy consumption. This infrastructure forms part of Glasgow's city-wide push toward becoming a smart city.

- The North Glasgow Integrated Water Management System is being delivered by Glasgow City Council, Scottish Canals, and Scottish Water under the umbrella of the Metropolitan Glasgow Strategic Drainage Scheme.
- Smart water management will create 55,000 cubic metres of extra capacity for flood water.²
- The new digital surface water drainage system is expected to unlock 110 hectares of land, capable of supporting the construction of more than 3,000 homes.³

“We can use the smart canal as an advanced SuDS system, linked to real-time information.”

Heather Claridge, Principal Planner, Glasgow City Council (Current: Director of Design, Architecture and Design Scotland)

1. Donnelly (2018)
2. Scottish Canals (2023)
3. Ibid.

THE BENTWAY, TORONTO Creating a public space underneath an expressway for community and art



Image: Andrew Williamson, courtesy of The Bentway

Designed by Public Work

LENGTH 1.75 KM WIDTH ~30M
INITIAL PRIVATE DONATION CA\$25 MILLION¹
MANAGEMENT THE BENTWAY CONSERVANCY
OWNERSHIP CITY OF TORONTO/WATERFRONT TORONTO

The Bentway project in Toronto is a remarkable corridor transformation that has revitalised an underutilised space beneath a major expressway. Spanning 1.75 kilometres, the project has transformed the area into a vibrant public realm that offers diverse experiences for the community.

The Bentway provides an urban oasis with recreational amenities, public art installations, and dynamic programming, making it a destination for both locals and visitors. It serves as a vital link between neighbourhoods, connecting communities and fostering social interaction.

The project was instigated by a private donation of CA\$25 million, delivered to the Mayor of Toronto alongside an initial vision.

With its thoughtful approach to placemaking, the Bentway has become an inspiring model for reclaiming neglected infrastructure and transforming it into a lively public corridor.

- The first phase of The Bentway is the result of a collaboration between co-founders Judy & Wilmot Matthews, the City of Toronto and Mayor John Tory, Ken Greenberg, Public Work, The Bentway Conservancy, Waterfront Toronto, and Artscape. The Bentway is located on the Treaty lands of the Mississaugas of the Credit, and is the traditional territory of several Indigenous nations.²
- Winter Skating at The Bentway attracted 57,400 attendees in the 2022/23 and earned the project in the range of 196 million media impressions.³
- The Summer 2022 season welcomed 102,000 attendees to free programming under the Gardiner and along public spaces in the surrounding neighbourhood.⁴

1. The Bentway Conservancy (2019)
2. The Bentway (n.d.)
3. The Bentway Conservancy (2023)
4. Ibid.

06

LEARNING ABOUT CORRIDORS

SIDETRACK

Hassell project image: Coast-to-Coast Light Rail
Extension, 2.8 km corridor in Adelaide, Australia
Image by Ben Wrigley © photohub.com.au

THANKS TO OUR CONTRIBUTORS

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SEAN DOLAN, Development Manager, Belfast City Council

Interviews were undertaken between May 2021 and May 2022.

Workshop participants (London)

ADAM SCOTT, Founder, Freestate
ALASDAIR GRAY, Associate Director, Civic Engineers (Current: Senior Associate, Stantec)
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CHRISTOPHER MARTIN, Co-founder, Urban Movement
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JOHN EMSLIE, Managing Director, Urban Flow
MARTIN KNIGHT, Director, Knight Architects
MARTIN WEDDERBURN, Founding Director, Wedderburn Transport Planning
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SIMONA CIOCOIU, UX Designer, Diagonal Works
TARA CLINTON, Senior Technical Officer, Infrastructure Coordination Team, Greater London Authority

The workshop was hosted on Microsoft Teams on December 16, 2021.
 Moderated by Camilla Siggaard Andersen, Research Lead, Hassell.

Workshop participants (Sydney)

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SARA STACE, Director of Cities, WSP
DR SCOTT HAWKEN, Landscape Architecture Program Director, University of Adelaide
THOMAS HALE, Senior Associate, Hassell (Current: Group Urban Design Leader, Warrent and Mahoney)
TOBY KENT, Co-Founder, EllisKent Consulting (Current: Partner, ESG Lead, PwC Australia)
YOLANDA GILL, Director, Western Parkland City Authority (Current: Director, NSW Land and Housing Corporation)

The workshop was hosted on Microsoft Teams on February 24, 2022.
 Moderated by Jon Hazelwood, Principal, Hassell.

Workshop participants (Shanghai)

LIU MINGYE, Hangzhou Grand Canal Group
YIN LU, CR Land
YE FENG, Shenzhen BLY Landscape, Architecture and Planning Design Institute
YIN XUEWEN, Urban Planning & Design Institute of Shenzhen
QIU MENG, West Bund Group
KANG XIAOHONG, West Bund Group
LU XIAOJUN, Urban Planning & Design Institute of Wuxi
QIN TIAN, Wuxi Natural Resource and Planning Bureau
LIU ZHICONG, Hangzhou Landscape Architecture Design Institute

Two workshops were hosted in Shanghai in April 2022.
 Moderated by Chong Wang, Principal, Hassell.

A SPECIAL THANK YOU

In the development of this report, data science consultancy Diagonal Works created a case study to explore how digital tools might be used to help weigh up competing objectives in corridor design.

Their study looked at the Ecoducto Río de la Piedad gateway in Mexico City, which is also included as a reference in this report.

As a basis to work from, Diagonal defined three realistic, but unofficial, objectives:

- **Cost:** make the structural design affordable
- **Access:** make the Ecoducto accessible to people in the local area
- **Proximity:** ensure access gates are close to public transit hubs (metro stations)

Using an optimisation model, Diagonal were able to provide insights into how early-stage design decisions could have long-term consequences.

“Optimisation has traditionally been a costly and slow process. As a consequence, few architects and engineers use optimisation analysis in the scoping and discovery phases of a project. But the opportunity to analyse complex, multi-system consequences as part of the design process can build stronger cases for bolder projects. Our analysis is powered by our own data model and analysis engine, which enables us to compute information about different scenarios, fast.”

Gala Camacho, Data Scientist, Diagonal Works

CASE STUDY: DIAGONAL WORKS

PROCESS



VISUALISATION



THE FULL CASE STUDY IS AVAILABLE ONLINE: [HTTPS://DIAGONAL.WORKS/POST/CORRIDORS/](https://diagonal.works/post/corridors/)

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