Active
Train
Stations

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Active Train Stations

Executive Summary

With the current climate crisis, it is time to reframe our understanding of active mobility as a solution for short journeys only. When combined with public transport, almost any journey can be an active one.

> An 'Active Train Station' is one with the necessary features to attract people to use the combination of rail, walking and cycling. These stations themselves will be conducive to active mobility, and will be supported with surrounding active travel infrastructure and neighbourhoods to enable people to choose sustainable end-to-end journeys.

To compete with private automobile travel, public transport must combine the speed of motorised transport (bus and rail), the reliability of dedicated right-of-way services (rail), and the flexibility of active transport through quality first/last mile active transport connections. Furthermore, the network must be well integrated with land use. By doing so, the feasibility of accomplishing one's daily activities without the need for the car increases, and becomes a more pleasant alternative.

This report takes a systems approach and examines the four components of a potential mid- to long-distance sustainable journey: Rail, Station, Active Network, and Neighbourhood.

From examining regions and countries where active-train trips are more prevalent than in the UK, we begin to understand where the deficiencies in our mobility systems and urban realms lie.

This study provides 20 actions to encourage active-train journeys. Some are specific to each of the components (e.g. rail service improvements, or active network enhancements), but many require collaboration across regions, and between local authorities, station operators, and train operating companies to offer a sustainable, reliable, and convenient alternative to private cars for journeys beyond the hyperlocal.

The co-benefits for health and wellbeing and thriving communities are also explored, highlighting that the active-train combination can truly be the best of both.
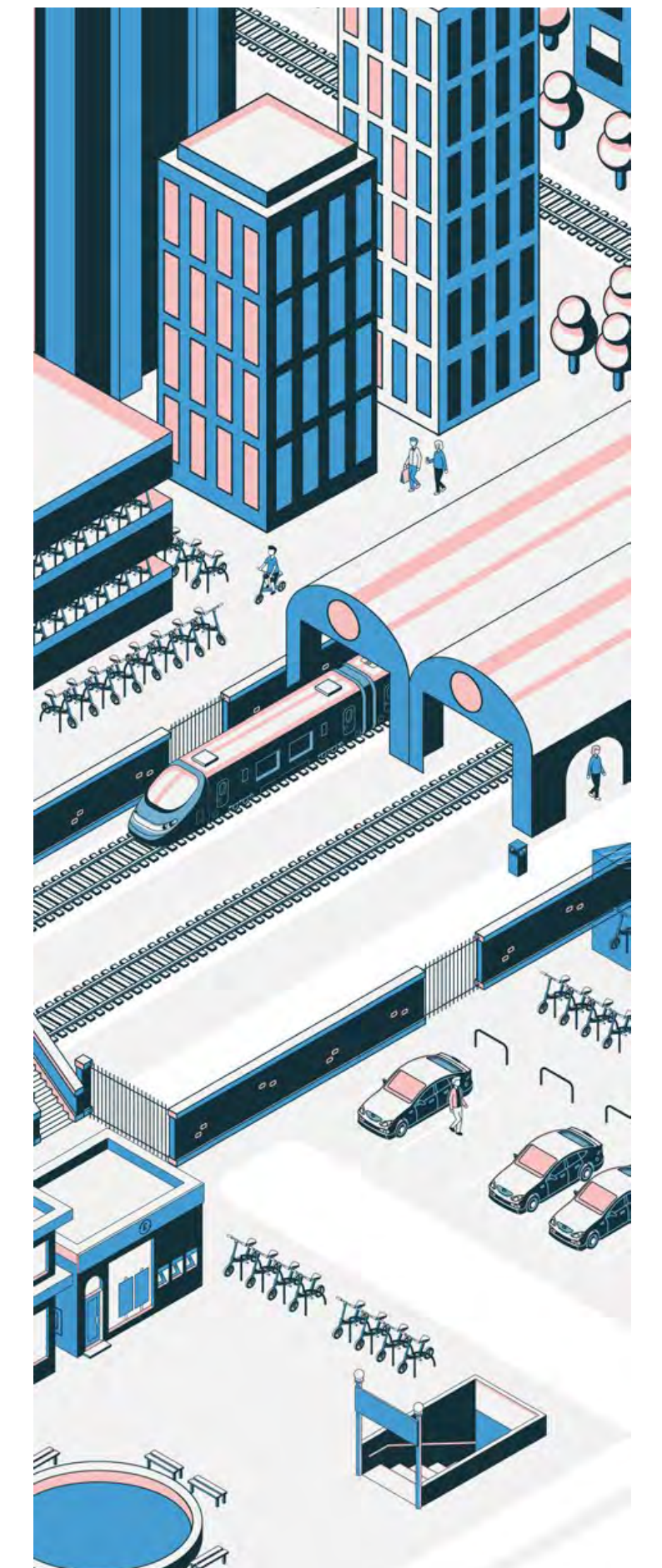
Executive summary

20 actions for door-to-door sustainable journeys
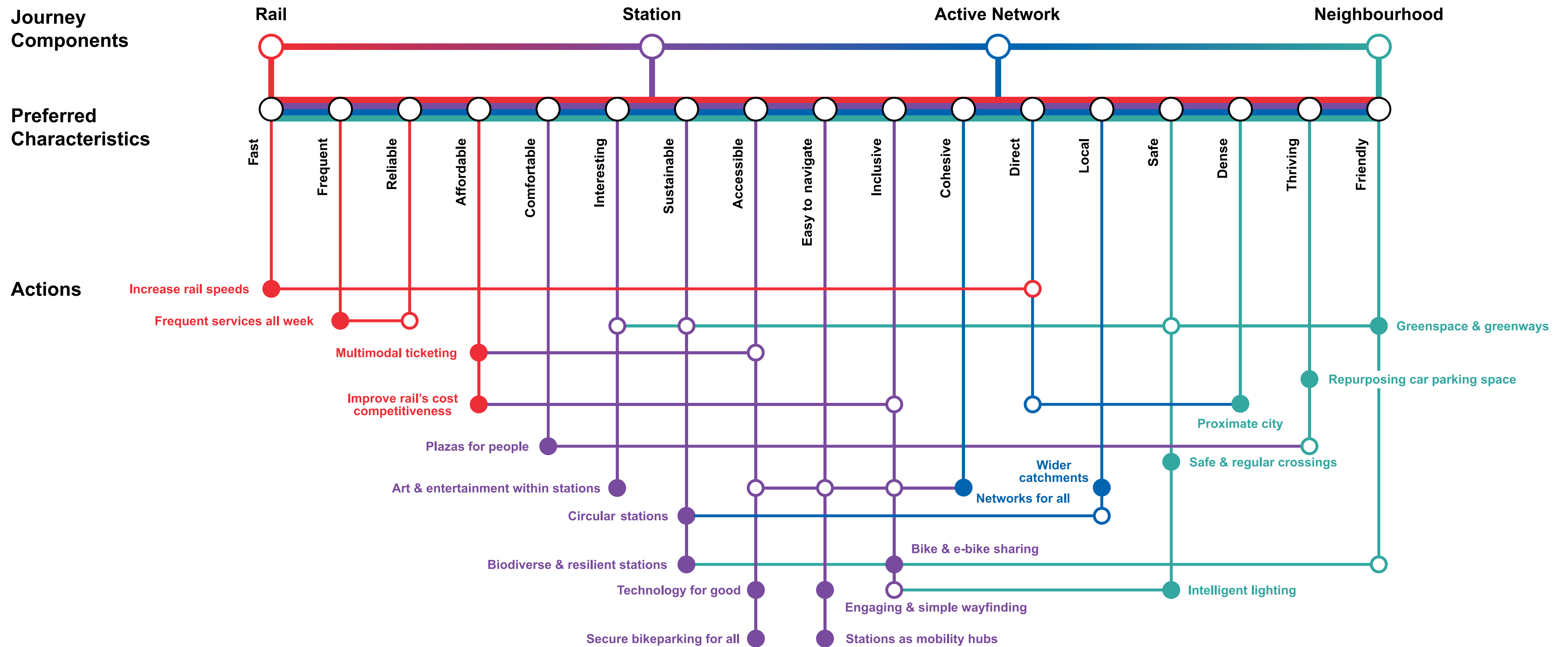
Introduction

# The direction of travel

The Challenge

The transport sector is commonly known as a stubborn, 'hard-to-decarbonise' sector. Globally, between 2010 and 2015 emissions increased by 2.5% annually, a higher growth rate than any other sector [1]. In the UK, transport makes up 27% of all domestic greenhouse gas (GHG) emissions [2], but significant change is required to meet Paris Agreement commitments on limiting global warming to 1.5°C [3].

Switching to electric vehicles (EVs) has been presented as a crucial pathway towards decarbonisation, however, this alone will not enable us to rapidly decarbonise. The Intergovernmental Panel on Climate Change (IPCC) report on 1.5 °C calls for structural changes within the transport sector, including reducing the demand for travel, and shifting away from low occupancy private cars towards more sustainable modes - public and active travel.

Analysis by the Institute for Public Policy Research (IPPR) suggests the current approach to decarbonising transport in the UK could see a 28% increase in car use by 2050, and an 11% increase in car traffic [4].

The transition to EVs was a focus of conversations at COP26, since it represents a more comfortable evolution of business-as-usual rather than substantial systems and behavioural change. However, the operational carbon from EVs is dependent on the electricity source, and aside from the continued emissions from brake and tyre wear from EVs, there are also the embodied emissions to consider. The manufacture of an average electric car produces nearly 12 tons of carbon emissions. This is equivalent to around 15 and a half years of electricity usage for the average UK family home [5]. EVs took centre stage at COP26 partly because we know how to plan for vehicles, whereas the path to de-motorisation is unfamiliar.

This all suggests that the other tools towards decarbonisation - active and public transport - need to be more urgently supported. A further challenge is decarbonising in a way that makes communities more resilient and liveable. This is not just a matter of changing fuel sources, but changing the allocation and organisation of space and how citizens are able to live within that space.
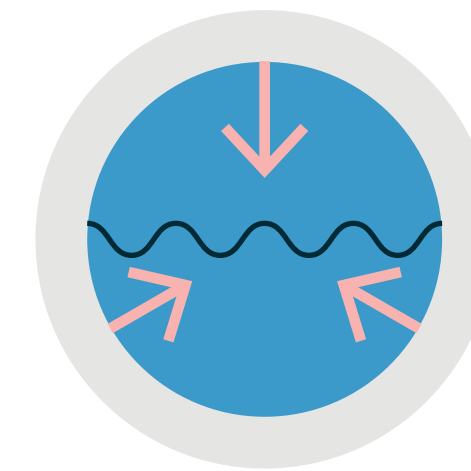
Avoid
Improving land use planning and digital connectivity to reduce the need to travel
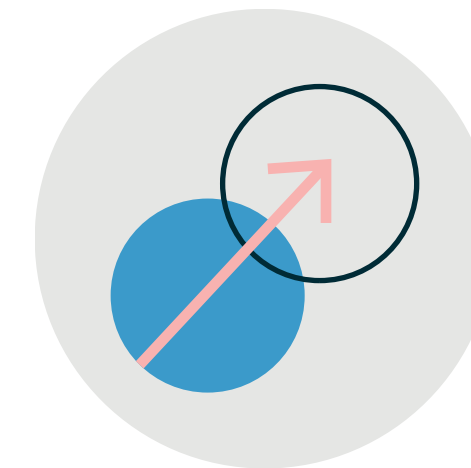
Shift
Shift journeys to more sustainable journeys: walking, cycling, wheeling, public transport

Improve
Use technology improvements to improve vehicle efficiency and reduce emissions per kilometre

The 'Avoid, Shift, Improve' framework
Adapted from giz, priorities for transport policy and investment attention

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Introduction

A rail revival

2021 was branded as the 'European Year of Rail', shining a light on rail as one of the safest, most innovative and sustainable modes of transport [6]. As a general picture, the industry across Europe has been progressing rail electrification programmes, to reduce the per kilometre impact of railway travel [7,8]. Ambitious measures, such as France's ban on short-haul internal flights [9], and the revival of inter-European long-distance and night trains indicate the investment and interest in replacing air travel with rail [10].

As a global community, we are also experiencing the implications of the COVID-19 pandemic. This has had a significant impact on train use, as a result of national lockdowns, increased home -working and customer concerns related to infection [11]. Between March and June 2020, customer levels on UK railways had dropped to 5% of normal levels [12]. Many customers have lost confidence in public transport due to mixed messages about safety, and the normalisation of private transport. Throughout 2020, with many businesses closed, and employees working from home, exercise was one of the few permitted activities in many countries, including the UK. This resulted in a revival in walking and cycling and policymakers became hopeful that this could represent a more permanent shift towards sustainable mobility and localism. Between 2019 and 2020, cycling levels increased by over 46% in the UK [13].

However, with an easing of lockdown restrictions and increasing vaccination, we are seeing that road traffic levels are recovering at a much faster rate than public transport. In October 2021, motor vehicle traffic volumes were only 2% lower than pre-pandemic levels (February 2020) [14]. This is despite the continuation of hybrid/ remote working. This would indicate that the 'new normal' optimists had hoped for, is looking much less 'new' and sustainable.

In most cases, COVID-19 offers two opportunities for the rail sector. It creates more retained wealth and spending in locations along a rail line, thus keeping local communities viable and more interesting. It also creates more demand further along railway lines, as infrequent commutes can be longer and still viable compared to daily commutes. That makes rail more viable as more people travelling less frequently, but over longer distances and spread more evenly across the day has the potential for less over-capacity in the peak, and thus more manageable networks.

We are at a mobility interchange. Can we use the momentum of increased environmental concern and the COVID-19 pandemic as an opportunity to reduce demand and shift to more sustainable travel? Or will business as usual return?

Lund Central Station
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Introduction

Combining active and public transport

The best of both

To encourage the use of rail over the private car, we need to assess the entire system: the rail network itself (frequency, speed, first and last trains, ticket cost, ticketing systems), the interchanges (station entrances, bike parking, services), the access (walking and cycling networks, safety, crossings), and the surrounding amenities (shops, doctors, schools, bus stops).

In urban towns and cities in the Netherlands and Sweden, walking and cycling are common choices for short trips. For longer trips, walking and cycling to and from train stations are more common than in the UK. In the UK, for trips less than one mile from train stations, 84% of rail users walk, however, above one mile less than 14% of rail users walk. For trips over a mile, over 50% use public transport (e.g. bus and light rail) to access railway stations, and 28% use cars, with less than 4% of station access trips made by bike [15]. In contrast, in the Netherlands, 40% of train passengers arrive at stations by bicycle, and in Skåne (Southern Sweden) 35% arrive by bicycle [16]. With similar climates to the UK, the evidence suggests cultural and infrastructural conditions may be obstructing UK residents from cycling to train stations. Other factors, including the availability of free car parking and the density of services around stations are also crucial considerations for active-train trips.

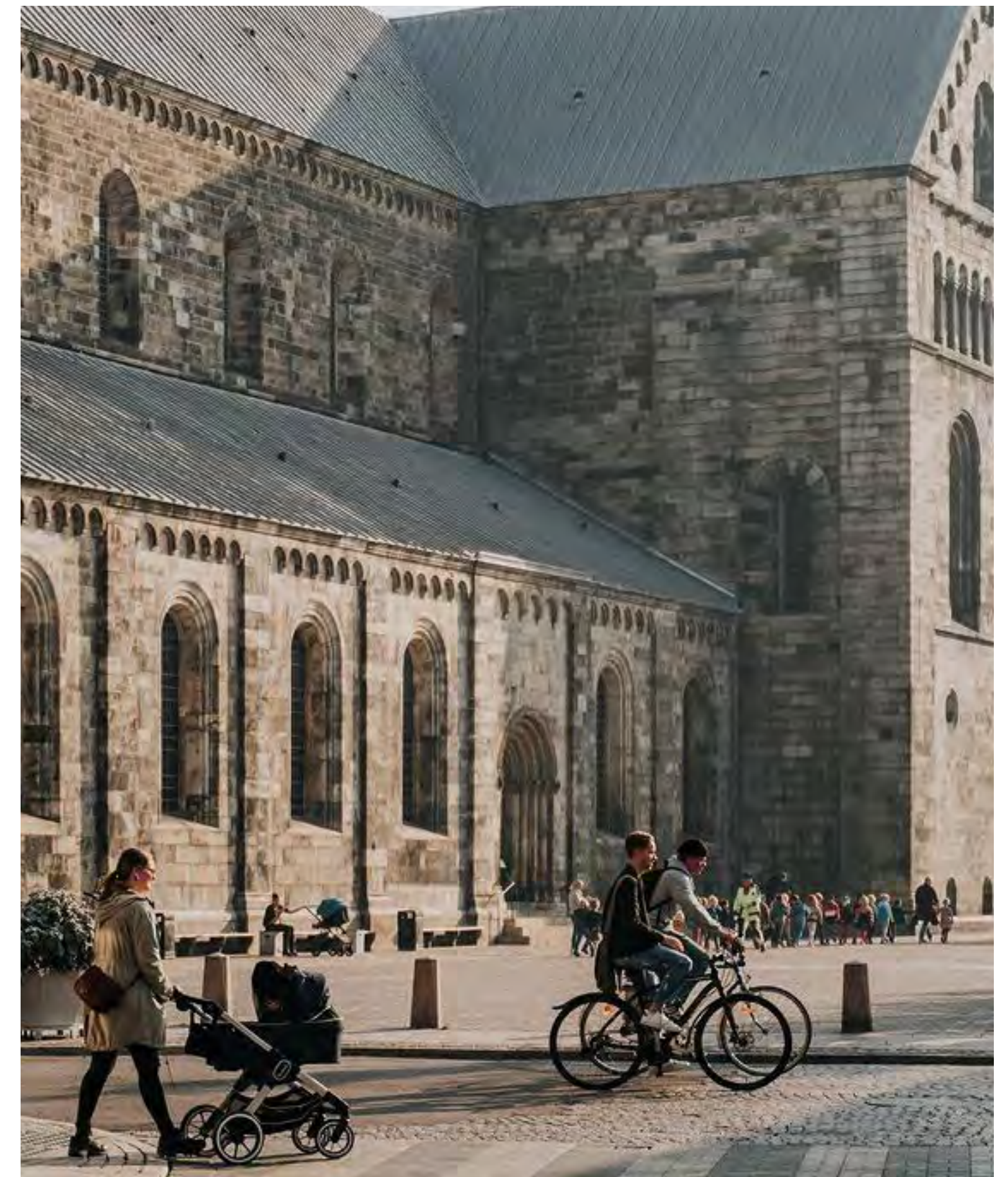Combining active and public transport modes is a way to combine the strengths of each mode, while unlocking a range of benefits. Walking and cycling give the user the opportunity to engage in physical activity, have no negative impact on local air quality, and enable door-to-door connectivity. Rail is fast and efficient, and when combined, the modes can truly rival the private car in terms of door-to-door high-speed journeys, but with the added benefit of it being more sustainable, healthy and safe.

Walking and cycling to train stations is typically free (some stations across the world charge small fees for highly secure bike parking), and allows flexibility in terms of trip chaining. Users can easily carry out daily tasks on the way to a train station without the burden of finding and paying for a car parking space - visiting local shops, dropping children at school, visiting pharmacies.

Far too often we are working in modal silos. Rail operators are concerned with punctuality targets. Station operators are interested in digesting footfall and customer satisfaction surveys. Local authorities work to improve walking and cycling paths throughout their towns and cities. There is rarely a joined-up strategy looking from the customer perspective about trips from door-to-door by a combination of modes. This is partly due to the responsibilities for different trip elements being split amongst different stakeholders, but also due to data collection and surveys typically being focused on the 'main mode' rather than trip stages. There are benefits for rail operators in working with local authorities and active travel organisations: seamless door-to-door journeys create greater farebox revenue as more people are tempted to shift mode.

Method: A European comparison

This study is focused on assessing the entire active-rail system. We take an international comparative approach, analysing these components on three inter-urban rail corridors in the Netherlands, Sweden and the United Kingdom. A particular focus is given to the following lines: between Amsterdam-Rotterdam via the commuter station, Hoofddorp; between Malmö-Helsingborg via the university town Lund; and between Glasgow-Edinburgh via the historic settlement Linlithgow. These are similar in terms of their geography, climate and distance, but differ in terms of the prominence of active access and egress.

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Beyond the journey

Co-benefits of active-rail journeys

What are the other benefits of active-train journeys?

Decarbonisation through a mode shift to active-train trips has the potential to bring a range of co-benefits for people and places.

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Air Quality

A switch from private car use to rail-active combinations can contribute to improved air quality through avoided emissions of air pollutants including NOx and PM. This can benefit those who have made this switch, as well as nearby communities. This is particularly relevant as nations pursue rail decarbonisation strategies to shift fossil fuelled trains to electric or other low-carbon alternatives.

Vibrant City Centres

A focus on promoting access and egress to stations through walking, cycling or other public transport modes could reduce car parking requirements. Land around train stations is high value land that should not be wasted. Cars are parked 95% of the time and, when cars are in use, they often carry just one person[17]. This space could be transformed into urban parks, gardens, community centres and libraries, or be converted to provide services for rail users (cafés, information points, cycle parking, seating). Permeable stations can also form a walkway and connect parts of communities.

Physical Activity and Better Health

There are health benefits from making a switch to using public-active combinations. The increased physical activity from walking/cycling to and from the station, as well as within it, can reduce the risk of a range of physical and mental health conditions including but not limited to heart disease, obesity, and lung disease [18].

Sustainable Economic Outcomes

People walking and cycling typically spend more time and money in city centres and contribute to local thriving economies. By reducing car traffic, city centres can become more pleasant places to spend time.

Investing in walking and cycling improvements can increase retail spend by up to 30% [19] and the retail spend associated with bikeparking per square metre is five times greater than carparking [20].

Active and public transport require less space than car infrastructure, unlocking space for city/town centre development.

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Beyond the journey

Co-benefits of active-rail journeys

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Decarbonisation through a mode shift to active-train trips has the potential to bring a range of co-benefits for people and places.

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Biodiversity

Shifting towards more rail-active trips can reduce the land needed for transport. On average, railways use 3.2 ha/km versus 9.3 ha/km for an average motorway [21]. Reducing the land for roads, parking, and the associated infrastructure frees up space for parks, city gardens and allotments.

Constructing new, or redeveloping stations is an opportunity to embed trees and plants in towns and cities and encourage biodiversity in a time of biodiversity decline [22]. Reducing the number of car journeys will also improve noise and air conditions for numerous species.

Productivity

Passengers can use the train journey as productive time to read, send personal communications, work, or completely switch off. Around 80% of business rail commuters use train travel time to work [23], something that is a unique option for rail compared with other modes.

Combining rail and active modes can also increase worker productivity outside of the train. People that are physically active take 27% fewer sick days each year compared with non-active colleagues [24].

Noise

High levels of noise have negative implications for human health – both physical and mental - and can disrupt local wildlife.

A mode shift to active transport significantly reduces local noise pollution. Although there is noise associated with rail travel, this is much more concentrated along rail corridors rather than city-wide, as with car traffic.

Reducing noise makes towns and cities more pleasant to spend time in and socialise.

Diverse Economy

Improving conditions and services for active-train trips can also have positive impacts for different customer groups, for example tourists. Staycations and rail use by domestic tourists has increased over the last few years. Improving rail services at weekends and connecting stations to local walking and cycling networks can make locations more attractive to tourists.

Rail can also cater for the night-time economy. Rail users can enjoy evening entertainment and visit local bars and restaurants, without worrying about returning to car parks in the dark or driving home.

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Beyond the journey

Co-benefits of active-rail journeys

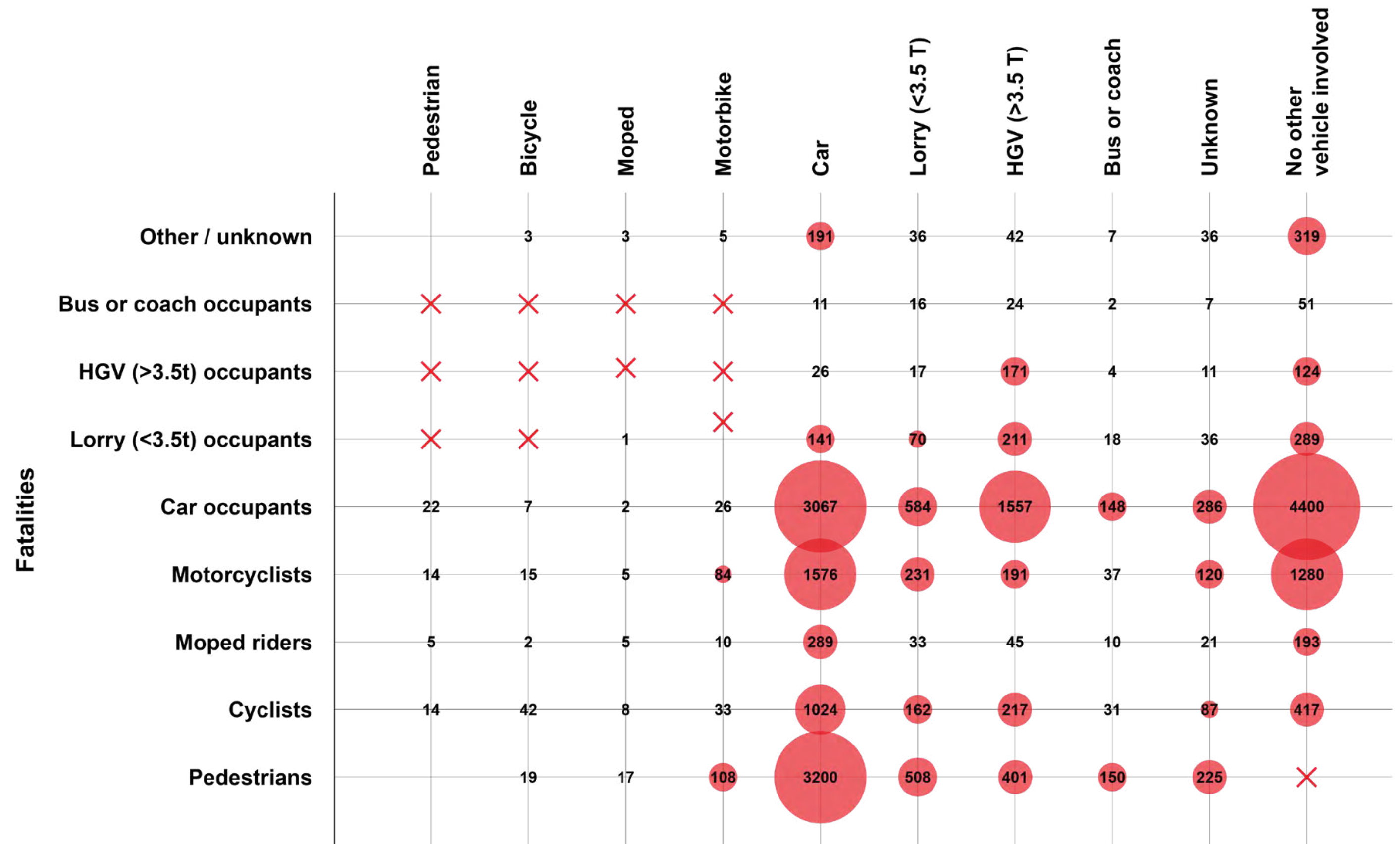*What are the other benefits of active-train journeys?*

Trains are one of the safest modes of transport

On dedicated networks with predictable traffic and a strong safety culture, severe accidents are rare.

A train journey is over 20 times safer than travelling the same distance by car [25]. This has been found to hold true during the pandemic [26] despite the risks associated with infection.

During the 2020-2021 Office of Rail and Road (ORR) reporting year only 10 deaths on the UK's railways were recorded [27]. There are still measures needed to increase safety for pedestrians and cyclists in many towns and cities [28] particularly where there are high car speeds and flows.

EU road traffic fatalities (2019)

In a collision with:

Fatalities	Pedestrian	Bicycle	Moped	Motorbike	Car	Lorry (<3.5 T)	HGV (>3.5 T)	Bus or coach	Unknown	No other vehicle involved
Other / unknown		3	3	5	191	36	42	7	36	319
Bus or coach occupants	✕	✕	✕	✕	11	16	24	2	7	51
HGV (>3.5t) occupants	✕	✕	✕	✕	26	17	171	4	11	124
Lorry (<3.5t) occupants	✕	✕	1	✕	141	70	211	18	36	289
Car occupants	22	7	2	26	3067	584	1557	148	286	4400
Motorcyclists	14	15	5	84	1576	231	191	37	120	1280
Moped riders	5	2	5	10	289	33	45	10	21	193
Cyclists	14	42	8	33	1024	162	217	31	87	417
Pedestrians		19	17	108	3200	508	401	150	225	✕

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Beyond the journey

Co-benefits of active-rail journeys

What are the other benefits of active-train journeys?

Social Spaces

Slowing down movement in urban centres and creating space for interaction can increase the sociability of towns and cities. The famous work by Donald Appleyard in the 1970s found that people were more connected with their neighbours when vehicle volumes were lower [29]. His work comparing the number of friends and acquaintances of residents from different streets indicated that light traffic neighbourhoods encourage social relationships.
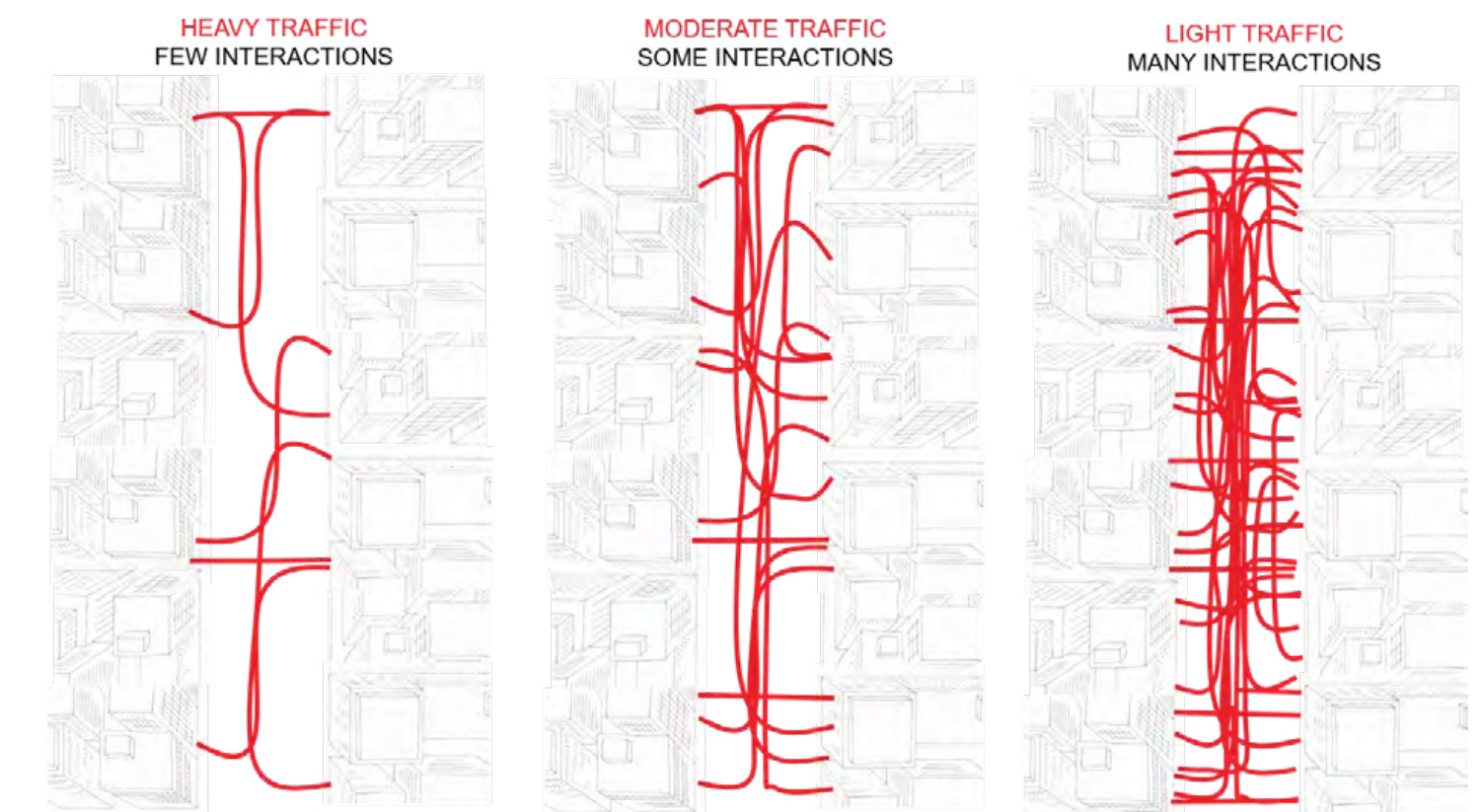
Stations and their immediate surroundings can be social spaces themselves. From community cafes and pop-up food trucks, to station meeting places and restaurants that become permanent features of the environment.

The same has been observed in many places around the world. Improvements to London's high streets were found to contribute to a 216% increase in people stopping, sitting and socialising [19]. Social spaces including parks, squares and playgrounds provide relaxation, stress alleviation and stimulate social cohesion within communities, resulting in mental health benefits.

Vehicles generally bring with them noise and pollution, which makes it uninviting to be outside. In these environments, citizens are encouraged to move quickly from A to B to minimise the time needed to spend in these unattractive spaces. Door-to-door transport by car also reduces the opportunity for interaction. Travelling by public and active transport encourages conversation and by travelling on foot or bike at slower speeds, people are more observant of and attached to their surroundings. These are again benefits of active and public modes that cannot be achieved through decarbonisation via electric vehicles.

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HEAVY TRAFFIC
FEW INTERACTIONS

MODERATE TRAFFIC
SOME INTERACTIONS

LIGHT TRAFFIC
MANY INTERACTIONS

Donald Appleyard's Liveable Spaces
© Donald Appleyard

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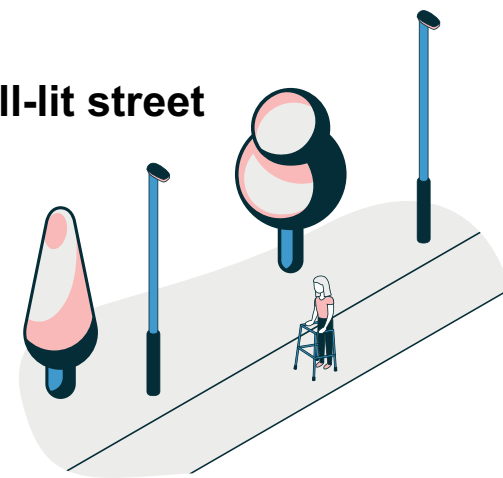
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Beyond the journey

Everyday aspects of active-train stations

Slowing down movement in urban centres and creating space
for interaction can increase the sociability of towns and cities.

**Using the station plaza
to meet with colleagues**
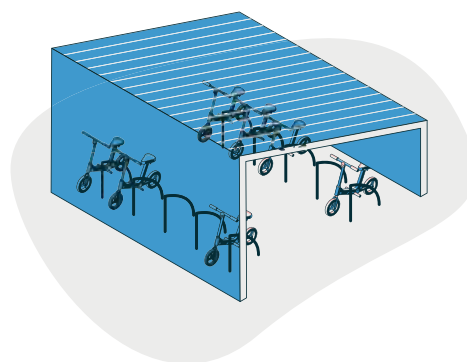
**Able to
exercise
outdoors**

**Reliable rail
for commuting**

Well-lit street
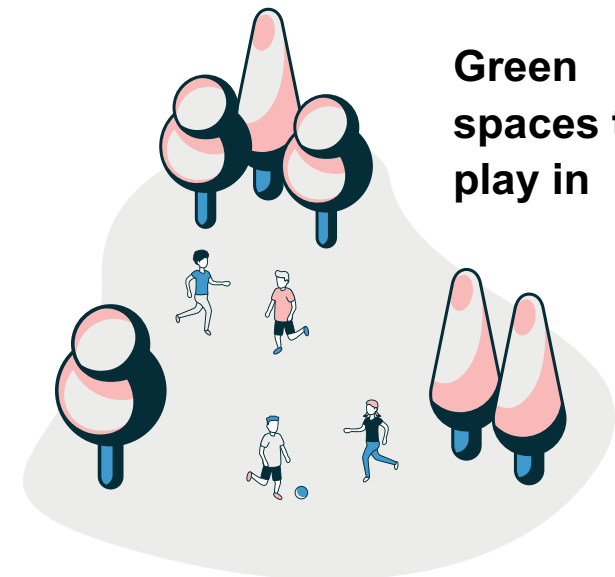
**Safe enough
to lock an e-bike**

**Green
spaces to
play in**

**Convenient way to
meet friends for leisure**

**Cycle path wide
enough to cycle
together**

**Reconnect
with nature**

**Affordable way to
travel to university**

**Investigate
affordable housing
without parking**

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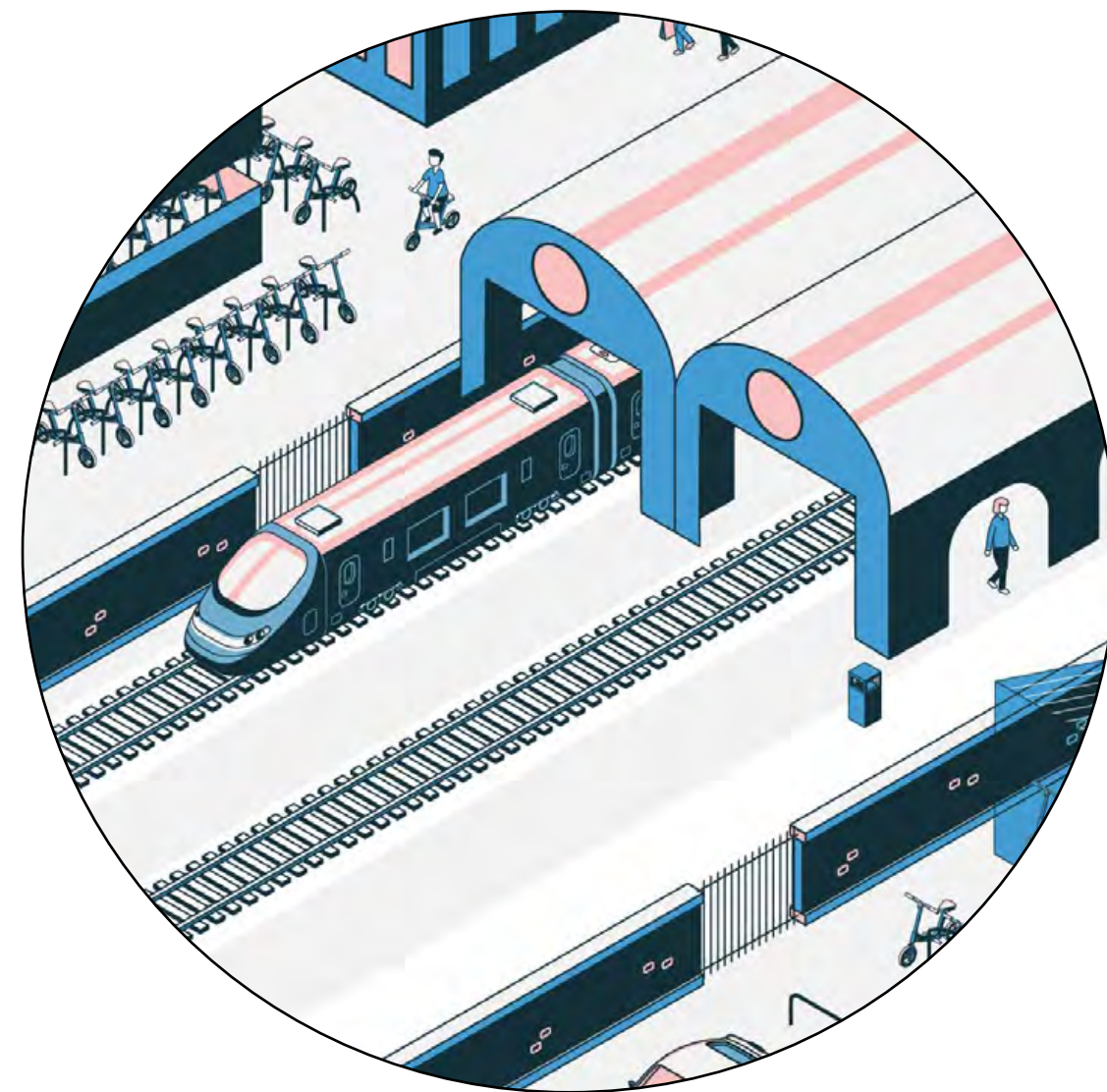
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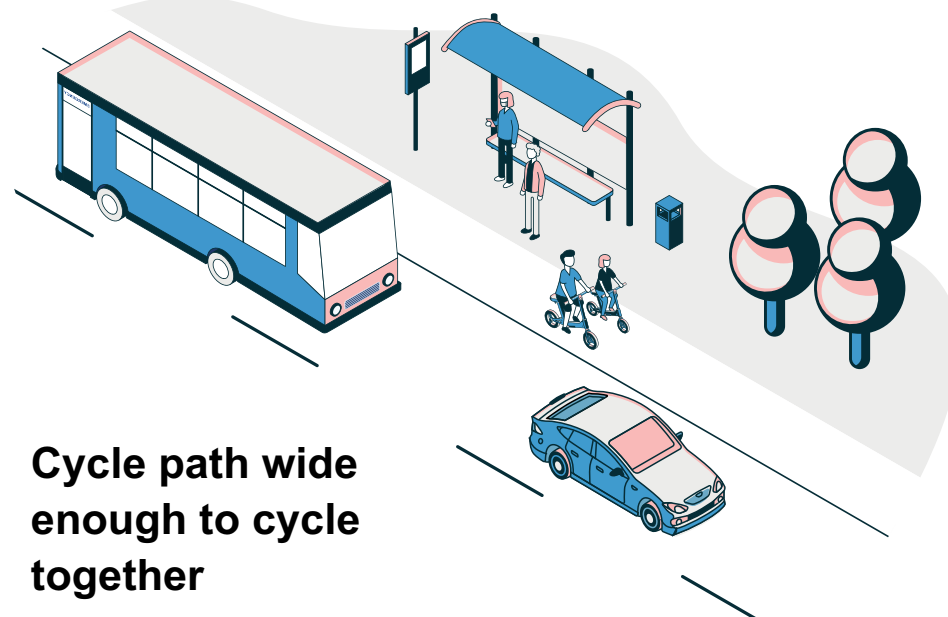
Measuring the quality of active-train combinations

Taking a holistic perspective of the active-train journey

An investigation into the individual components of an active-train journey

The Rail Service

As the starting point, the Rail factors category covers whether rail is a feasible, convenient and/or an attractive mode. Without a reliable, regular and affordable rail service, an active-train combination would not even be on the table.

The Station

Secondly, as the site of modal interchange, considering station quality is essential. A range of quantifiable metrics are included in this category: platforms, entrances, waiting rooms, bike parking, bike hire, convenience stores and accessibility requirements. The placemaking elements that make a station feel like an attractive place to travel through and wait at are also explored.

The Network

Without a suitable active travel network, travellers are less likely to even consider active-train combinations, or derive satisfaction from them. Factors such as gradient, surface, crossings, segregation, lighting and street trees are considered here. Ensuring the network is inclusive for everyone is another key category for analysis.

The Neighbourhood

To promote trip-chaining and encourage sustainable onward travel at the end of rail trips, the 15-minute neighbourhoods around stations need to offer a range of amenities including green space, leisure, food stores, education, health facilities, indoor and outdoor fitness centres, and benches to rest.

The Rail Service

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The Rail Service

Provide an attractive rail offering

On the right track

The rail offering is arguably the most important of the factors, within the rail-active trip combination. The rail offering needs to be competitive, convenient, affordable and reliable.

Even in bike friendly cities, car use can still remain high if there is not a suitable rail service to out-compete the private car. For example, Paris has been making great improvements in active travel provision over the last couple of years under the leadership of Mayor Anne Hidalgo. The number of cyclists has increased by 54% over 2020, but the ageing and unreliable rail system means that car use is still higher than it might otherwise be [30]. In this case, walking and cycling can replace short trips, but in order to truly decarbonise the city and city region's transport network, improvements to the rail network are required.

Frequency

Frequency is an important factor for promoting a mode shift to rail. Regular services reduce the burden on passengers for journey planning and reduce waiting times on arrival at the train station.

Network Rail recognise the importance of frequent services and are planning for an additional 11,300 services a week by 2025 [31].

Reliability

Making comparisons across countries for rail reliability is challenging. Different metrics on arrivals, departures, and lateness thresholds (1-5 minutes) vary. The most comparable data suggests that the Netherlands (95%) and Sweden (89%) have higher percentages of passenger arrivals classified as 'punctual' than the UK (86%) (N.B. the EU27 average is 90.2%)[32].

First and last

A comparative analysis of inter-urban lines in the Netherlands, Sweden and the UK indicate substantial differences in passenger rail provision. Between Lund and Malmö on the Malmö-Helsingborg line there are 170 services per day. This is far ahead of the Edinburgh -Linlithgow and Hoofddorp-Amsterdam frequency.

Often rail quality analysis only looks at the peak weekday periods, but a network is only as strong as its weakest link. In the UK the weakest link is at the weekend, particularly Sunday, where the number of services falls by over 25% compared with Saturday/weekday services, and only begins from 8am. Having a poor weekend service makes it less likely for individuals to forgo car ownership; in some industries individuals work at the weekends, and others still want to travel for leisure, social and personal business purposes on Sundays.

Edinburgh Waverley Train Station
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The Rail Service

Address weak links in the timetable

The Sunday Trading Act, permitting shops to trade on Sundays was passed in the UK in 1994 [33]. Since then, Sunday has ceased to be the traditional 'day of rest' that it once was. Citizens must travel to work in retail and other sectors on Sundays and therefore rail services need to increase in order to facilitate this.

In Sweden there is a transition towards 24-hour rail provision, and in other European countries there are similar ambitions to reduce the importance of passenger timetables. For commuter and metro rail in the Greater Copenhagen Region the trains are very frequent. Here waiting more than five minutes for a train is becoming less common. This can reduce stress for users and the need to rush for a train within an infrequent service pattern.

		Rail Frequencies																								
		Hour																								
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	**Total/day**
Lund-Malmö	Tuesday	4	2	1	2	3	7	8	9	9	9	10	8	10	8	9	8	10	9	8	9	9	7	6	5	**170**
	Saturday	4	3	3	2	3	4	5	6	7	6	8	6	8	6	7	6	7	6	6	7	7	7	6	5	**135**
	Sunday	4	3	3	2	3	4	5	7	6	6	7	7	8	6	7	6	7	6	6	7	8	9	5	5	**137**
Linlithgow-Edinburgh	Tuesday	1	0	0	0	0	0	4	7	4	4	3	3	3	3	3	4	4	5	4	5	4	4	4	3	**72**
	Saturday	1	0	0	0	0	0	4	6	4	4	3	4	3	4	3	3	4	5	4	5	4	4	4	3	**72**
	Sunday	0	0	0	0	0	0	0	0	2	3	4	3	5	4	3	5	4	3	3	3	3	3	3	2	**53**
Hoofddorp-Amsterdam	Tuesday	2	0	0	0	0	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	**77**
	Saturday	3	1	0	0	0	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	**77**
	Sunday	2	1	0	0	0	1	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	**75**

Comparison of rail services on selected European routes [33, 34, 35]

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The Rail Service

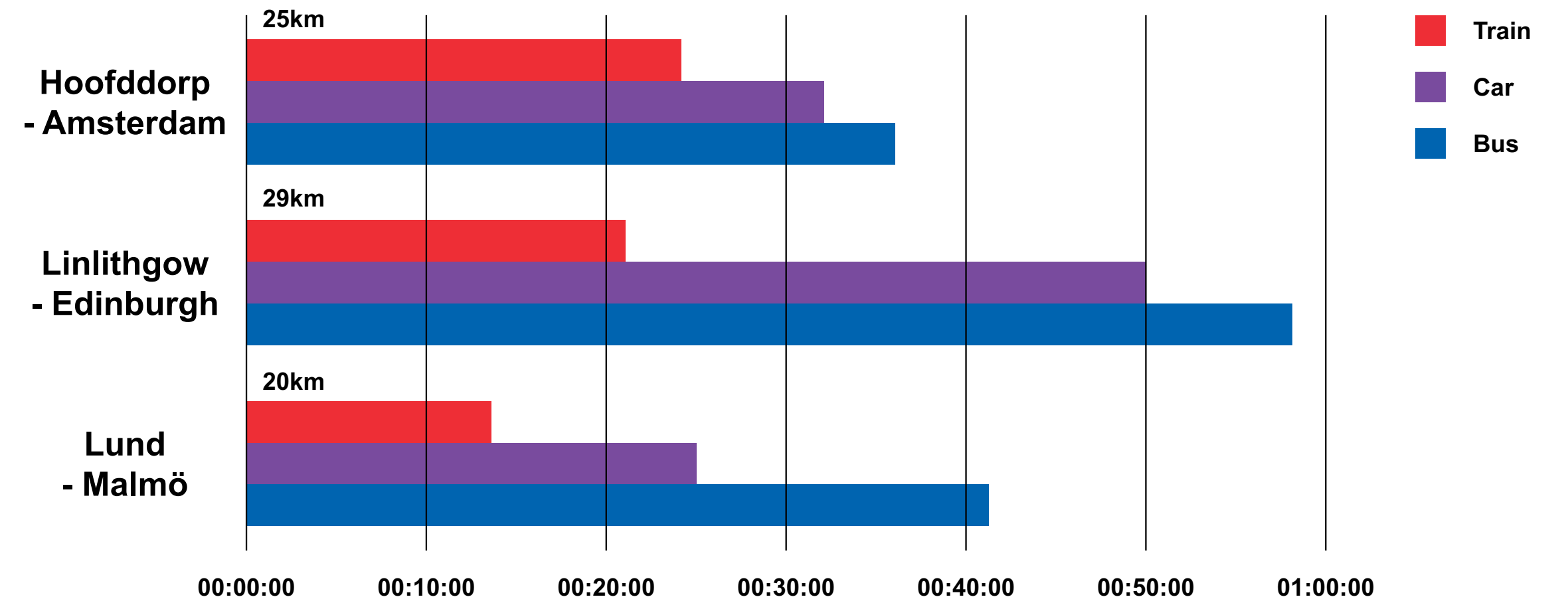# Reduce the costs of rail travel

Speed

Speed is another consideration for mode choice and for all three of these routes, the train offers the fastest option. In the UK the journey time by rail is much more competitive than either of the road transport modes: ~21 minutes by train versus 50 minutes by car and 58 minutes by bus. In the Netherlands and Sweden the difference is less stark, but in both cases rail is faster than both car and bus.
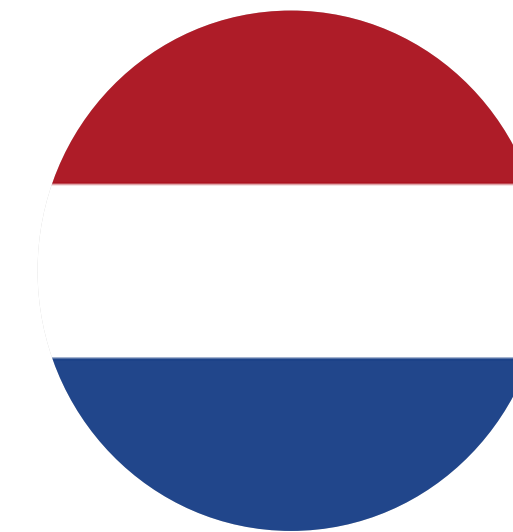
Cost

Across the three routes, costs were very consistent at 20-21 pence per kilometre, considering both single and return adult journeys. This suggests alignment across the three countries in terms of revenue models. However, what this comparison does not consider is that the Swedish train ticket between the two stops also provides free access to Skanetrafiken bus routes within the towns and cities of origin and destination. For example, a 24 hour ticket between Lund and Malmo would enable a user to travel on the bus from their home to the train station, take the train to the destination and then continue their onward journey to their final destination within the town/city boundary all on the same integrated ticket [37].

While customers complain of rising prices, it is important to consider the whole life costs of car ownership that are hidden but included in each kilometre travelled by car. Many drivers disassociate costs such as insurance, MOTs, and maintenance costs from their journey cost calculations. Drivers in the UK underestimate the cost of driving by 60%, and in Germany by a similar 58% [38].

The purpose of this study is not to do a detailed evaluation of punctuality, overcrowding and other factors related to the customer experience, yet it is clear that cost and value for money are two different concepts.

Average Travel Time

	Train	Car	Bus

Hoofddorp - Amsterdam (25km)
Linlithgow - Edinburgh (29km)
Lund - Malmö (20km)

00:00:00 00:10:00 00:20:00 00:30:00 00:40:00 00:50:00 01:00:00

Single and return journey costs

Sweden: £4.27 | £8.55 (21p per km)

Netherlands: £5.05 | £10.10 (20p per km)

UK: £5.90 | £11.40 (20p per km)

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The Rail Service
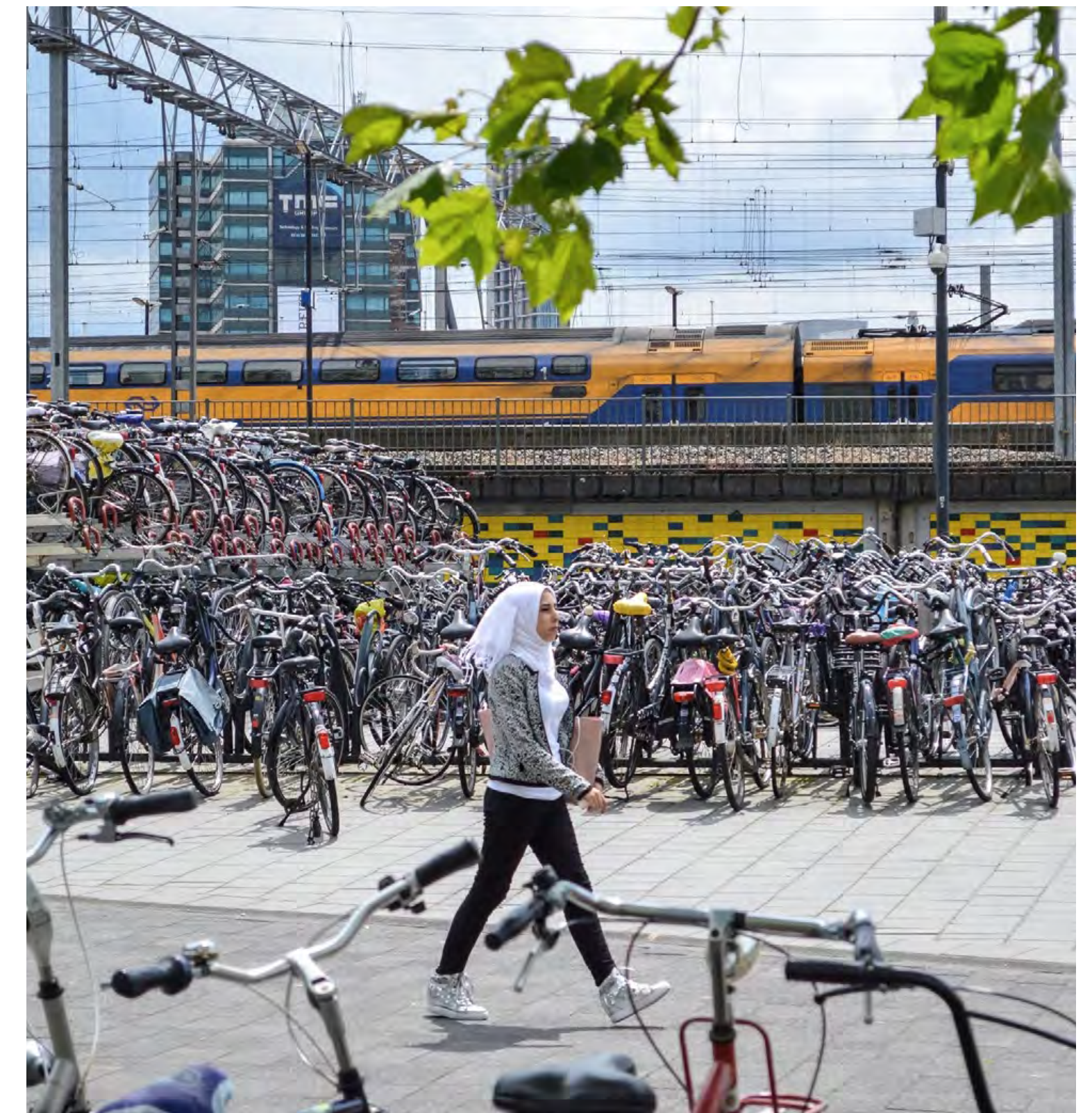
Safe and attractive journeys for all

Part of providing an attractive rail offering is designing and operating for different user groups, and considering how age, gender, culture and other factors change requirements and experiences of train travel[39].

Around 25% of adults in England are diagnosed with at least one mental illness according to the Health Survey of England[40]. A recent UCL study found that better behaviour by other travellers was a key factor in encouraging those with mental health conditions to use the train more frequently [41].

In response to poor behaviour from other passengers, Transport for London (TfL) has introduced an announcement on trains and platforms to remind passengers to "look up" and see whether someone else requires their seat more than they do. This encourages people to actively give up their seats for those with conditions that make them less able to stand [42].

Anti-social behaviour on trains can make passengers feel uncomfortable or unsafe. Installing CCTV and regular on-board and station messaging are measures that can be used to improve safety on trains. The Department for Transport (DfT) recommends that customer-facing staff have access to radios and appropriate training to deal with difficult situations[43]. The design and condition of the stations and trains have a high impact on passenger behaviour. Well maintained and clean spaces typically improves behaviour.

Alcohol consumption has been linked to anti-social behaviour on board trains. ScotRail and TfL do not permit the drinking of alcohol on their trains. In Sweden, the national operator SJ only allows purchase and drinking within specified bistro carriages only. Most operators in England permit the purchase and/or drinking of alcohol but reserve the right to ban this on certain services (e.g. to and from sporting matches)[44].

Station Bike Parking
© Dutch Cycling Embassy

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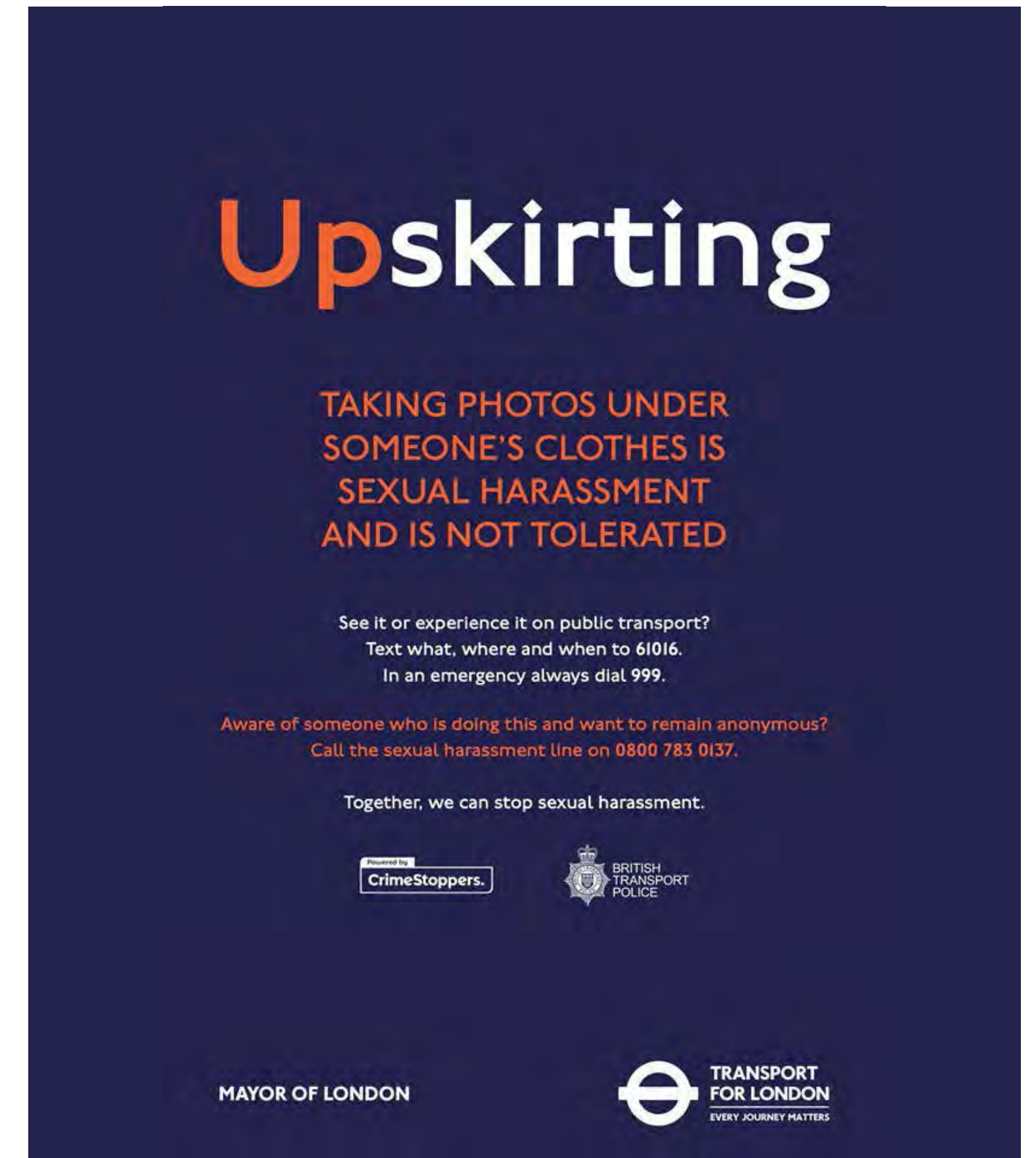# Ensure women's safety on public transport

Keeping women safe on board

Across the world, women are on average 10% more likely to feel unsafe when using public transport than men[45]. In the UK's capital, this is a growing problem. Over 50% of women in London have been victim of some kind of unwanted sexual behaviour[46]. These types of statistics have prompted TfL and National Rail to run campaigns to raise awareness amongst customers related to anti-social behaviour and sexual harassment.

In London, TfL have used a range of eye-catching posters as part of their campaign with The Rail Delivery Group (RDG), British Transport Police (BTP), Metropolitan Police Service (MPS) and women's safety groups. TfL calls out specific behaviour that won't be tolerated on trains and buses: exposing body parts, upskirting, touching, staring, rubbing against people on purpose, cyber-flashing and catcalling.

Similarly, Network Rail's campaign aims to foster a safer and more respectful environment for customers and railway staff.

National Rail anti-sexual harassment campaign (below)
© National Rail

Transport for London's current campaign (above)
© Transport for London

The Station

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As the site of interchange between modes, stations are at the heart of the user experience

First Impressions

A train station is often the first impression of a place, so the station and its integration with the urban environment are important for urban vitality and can act as a catalyst for future development. The experience of train stations is very much central to the customer experience, and facilitates the possibility of rail-active combinations. Stations are the entry point to the railway and are the interchange between modes, and are therefore a key part of the puzzle.

Features of well-designed stations:

– Enable seamless interchange between modes;

– Sit within their local context (they do not feel out of place);

– Are located centrally, close to the main hubs of activity - retail, education, leisure and employment centres;

– Are usually places with good onward transport connections (bus, tram, metro);

– Are pleasant, safe and inclusive places to be.

– To improve the overall train experience, interventions can be applied to several aspects of the diagram.

– Reduce journey times, which will reduce the overall journey times and increase the proportion of high value time at origins and destinations. This is typically achieved through engineering works at railway pinchpoints, electrifying railways or moving to high speed networks.

– Increase the value of time for access and egress, for example by switching to walking or cycling which accrue physical and mental health benefits during the journey. This value can be further increased if the active travel network is safe and comfortable.

– Reduce the transfer time

– Increase the value of the transfer time (e.g. enable passengers to shop, eat, carry out tasks using station WiFi)
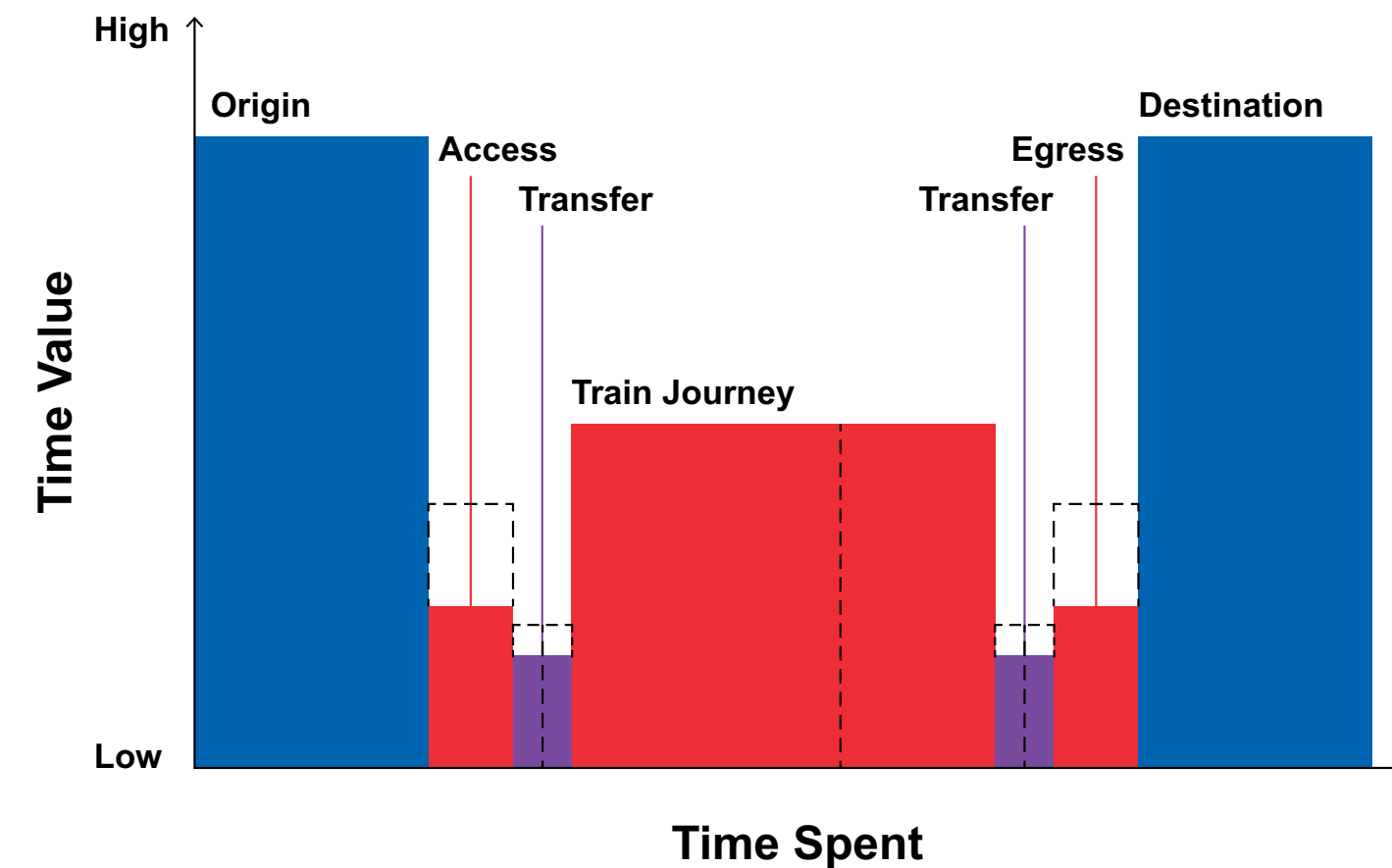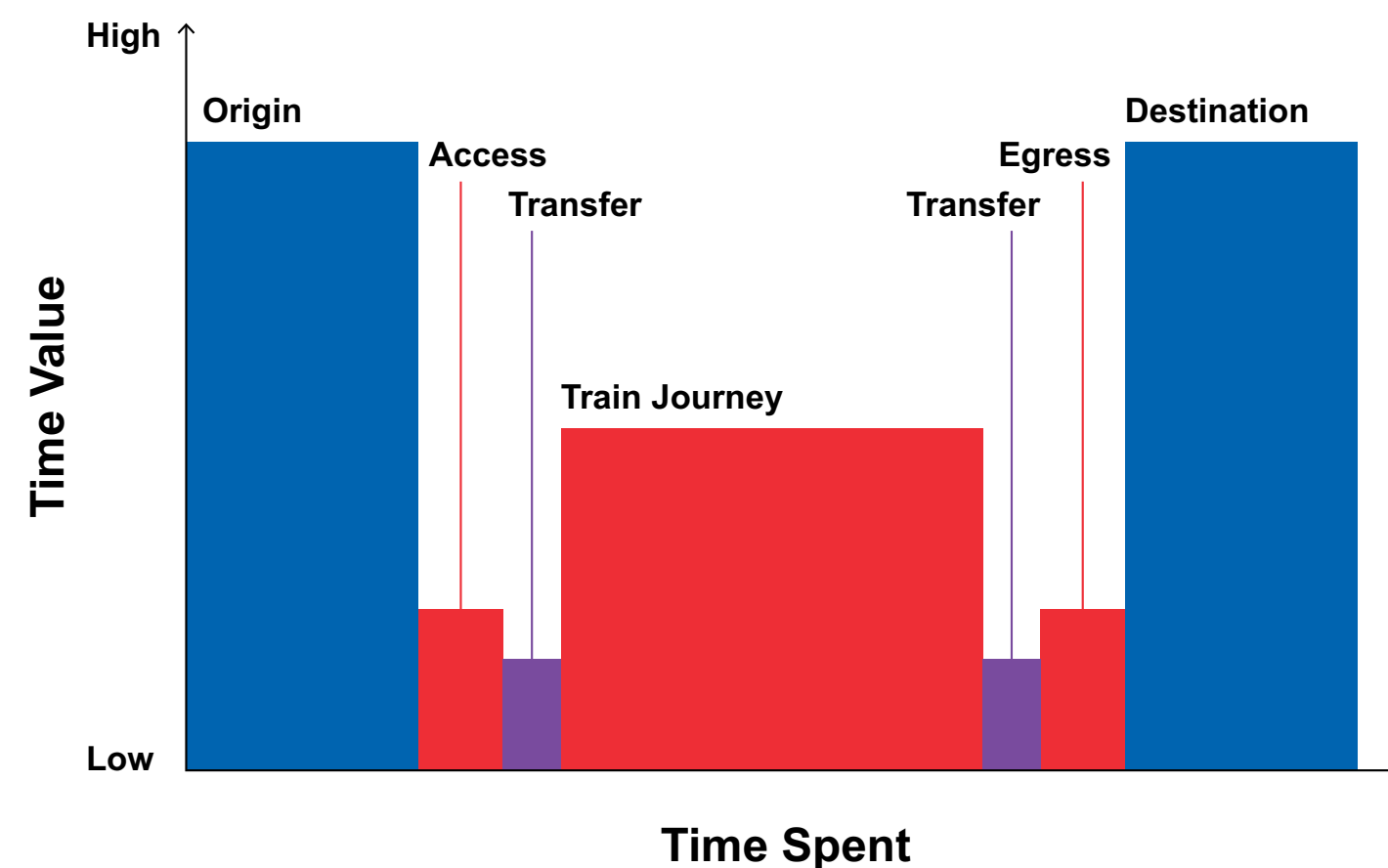
Improving the door-to-door value of a train journey
Adapted from IEE Railway Station Design [44].

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# Consider the impact of station size

Considering station size

The role and expectation for the station very much depends on the size of the location and the subsequent passenger flows through the station.

British stations are categorised according to size from A (largest) to F (smallest). The majority - over 80% - of stations are classed as small to medium (D, E and F) [48].

Stations need to be resilient to long-term changes in use and demand. Even smaller stations can have passenger congestion issues, particularly when there are popular cultural or sporting events on. When estimating the demand, a general rule of thumb is to add 25% to factor in disruptions. Network Rail have outlined a range of passenger densities from Level of Services (LOS) A as free-flowing passenger movement, to LOS F as scenarios where walking is difficult.

Crowded stations should consider multiple information boards, waiting rooms and toilets to avoid overcrowding around these points. Digital technology should also alleviate this, with real-time information on mobile apps reducing the need to crowd round physical boards in the station.

DfT Station Categorisation
Source: Network Rail Station Design
Guidance [46]
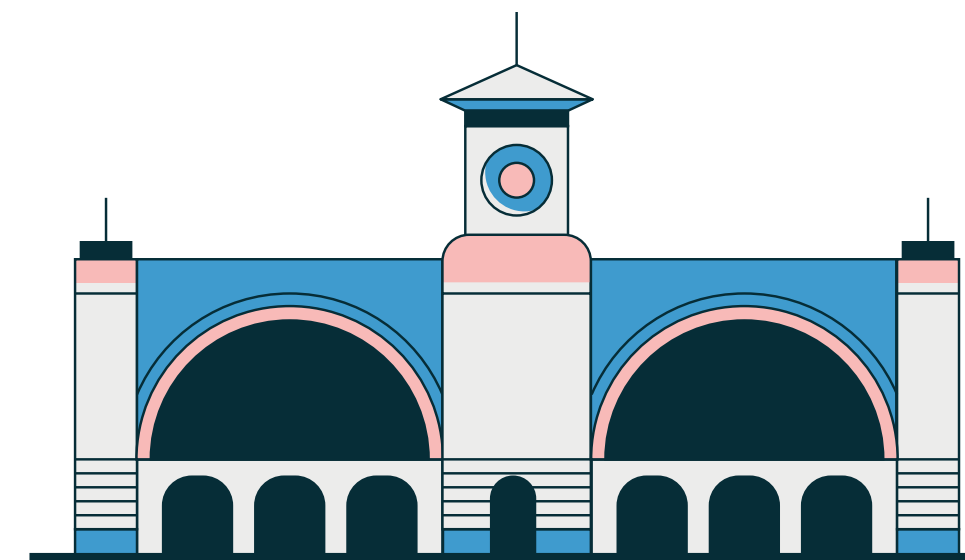
A - National Hub

(e.g. London Kings Cross)
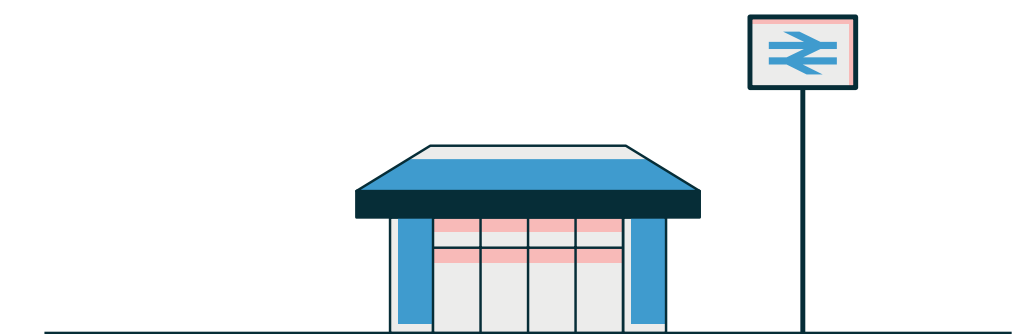
> 2 million trips/year
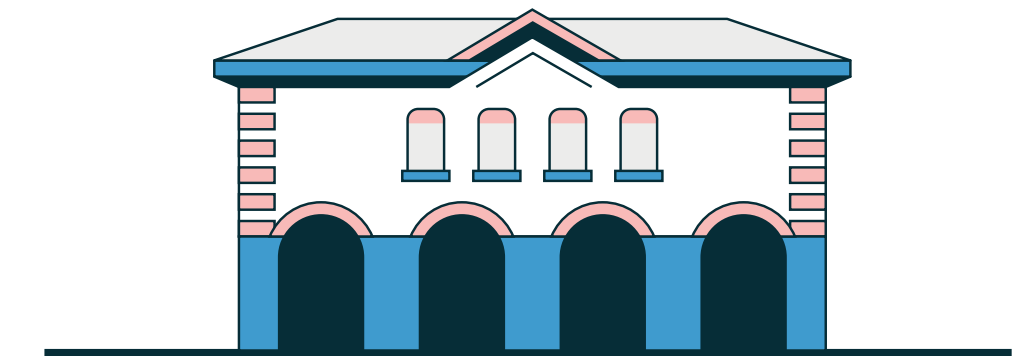
B - Regional Interchange

(e.g. Cambridge)

> 2 million trips/year
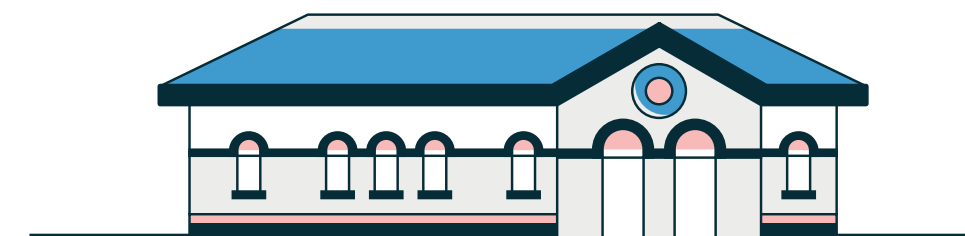
C - Important Feeder

0.5 - 2 million trips/year

D - Medium Staffed

0.25 - 0.5 million trips/year

E - Small Staffed

< 0.5 million trips/year

F - Small Unstaffed

< 0.5 million trips/year

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Improve the waiting experience

Stations need to be pleasant spaces to transfer through, arrive at and wait in. On average, passengers spend seven minutes at a station and most of this is waiting on the platform. Typically, passengers overestimate how long they spend waiting, and this is particularly the case when there is nothing to do [47]. Providing a range of services can reduce the feeling of boredom and increase utility whilst waiting, and therefore make the mode more attractive.

Network Rail, who operate 20 of the UK's busiest train stations, have set out their Station Improvement Plan [50] which includes a range of measures to improve the experience within stations:

– Adding and improving seating for those waiting;

– Removing charges to use station toilets;

– Free water refill stations;

– Working with brands to improve the retail experience of stations;

– Free and fast Wi-Fi in stations.

In Copenhagen there is an on-going debate about the role of stations in promoting local living and small businesses. In some stations, rather than having branches of large multi-national cafes and eateries, there is an opportunity to promote local traders, and increase the sense of local identity.

In the Netherlands, some smaller stations are already developing a local identity with the introduction of local cafes and florists.

Barneveld Noord, Rotterdam
Modular station design by NL Architects using a collection of repurposed containers. The refurbishment was part of ProRail's 'Pleasant Waiting' programme to improve the passenger waiting experience at stations. There are different containers for waiting, a café and ticket purchase. Source: Marcel van der Burg [51].

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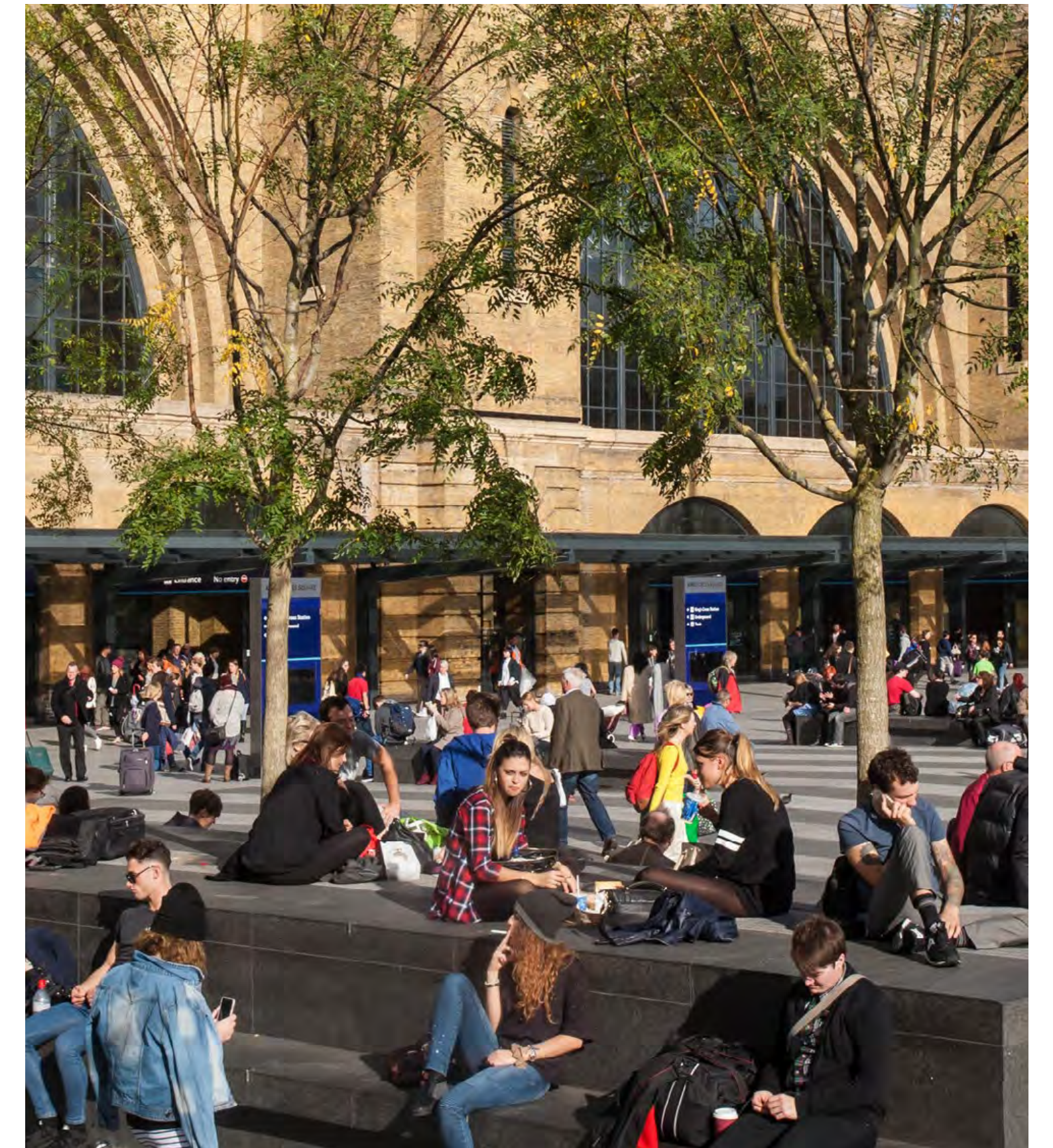
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Beyond boarding

More and more, we are seeing that stations are places for other activities beyond boarding trains and are becoming places of surprise and delight. Research has shown that 25% of visitors to train stations are there to benefit from other services aside from boarding trains [52]. This trend has really accelerated following the redevelopment of Kings Cross railway station which is now a cultural and retail hub in London. In Paris, the French Post has installed 120 lockers under the Collect & Station scheme to add another service within stations [50]. Retailers in Swiss train stations have longer trading hours than on the high street, making the station a market for different users.

Research has shown that people can 'save' about 13 minutes at a station by doing things at stations that they would otherwise do somewhere else on the same day, such as shopping or eating. This is one of the other selling points of rail over other medium-long distance modes [53].

The key in designing a station is to first eliminate the negative elements and then stimulate the positive (if basic needs aren't met then they are not open to additional positives). When working to improve stations it is important to distinguish between 'must' and 'lust' motives [47]. Must motives are related to accessibility, clarity of information, and easy interchange. Lust motives are the 'nice-to-haves' that improve the experience but are not fundamental to everyday navigation and operation. Must motives are what is important to a customer during 'stress mode': when they are navigating the station during rush hour to get to a destination. Here a passenger looks for short walking distances; transparent open space with clear guidance; no/minimal unnecessary stimulants; and predictable and recognisable signposting. Lust motives are more relevant when passengers are in 'relax mode', when they know their journey and have additional time to browse. It is often wise to have 'fast' and 'slow' areas within a station to separate out different user types. Decision points should be carefully thought through to avoid waiting in congested parts of the station.

It is also important to distinguish between different passenger profiles at different station types. First time/international passengers at large stations will typically need more support than commuters at local stations.

London King's Cross Railway Station
© Arup

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As the site of interchange between modes, stations are at the heart of the user experience

Lighting and colour

In stations, lighting has a dual function. Firstly it has an inclusive design and safety function, and then a secondary function related to ambience and architecture. The impact of lighting and colour selection on customers has been widely researched in a number of fields, particularly across the retail sector. General findings suggest [54]:

– Short wave colours such as blue have positive responses of pleasure, dominance and arousal (hence why blue is used as the dominant colour of many well-known logos). Blue has also been found to bring a positive feeling of safety.

– Long wave colours such as red typically increase feelings of danger. Red also alerts users, making it a commonly user colour in signage.

– Diffuse and bright light is perceived positively, whilst dim light is perceived negatively.

In general, natural lighting should be utilised where possible. These open spaces also allow people to see their targeted destination and aid navigation.

Entrances

The entrances to stations can be challenging places. Multiple modes coming together with bus stops, taxi ranks, bike parking and pedestrians. This all needs to be organised carefully to avoid collisions and to improve safety and security. The sustainable transport hierarchy should guide our approach to wayfinding in relation to the station entrance. Well-designed entrances can also help with permeability and connection between the station and surrounding community.

© Arup

Signage and wayfinding

Signage and wayfinding around and within the station should be consistent, clear and easy to understand. Special attention should be taken to improve legibility for the visually impaired, and simple symbology like arrows will help tourists and other infrequent visitors. Collaboration between station operators, local authorities and active travel groups (e.g. Sustrans) is crucial for signage related to mode integration.

Wider neighbourhood maps including the station, cycling networks and key land uses could be used to help with onward journeys. Directions to pedestrian exits, bike parking and bike hire should be easy to find.

Station wayfinding branding
© Scotrail

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Convenient cycle parking

Cycle parking

Cycle parking is one of the main areas where UK stations fall behind their European counterparts. To facilitate active-train combinations, stations should be fully accessible and attractive for pedestrians and cyclists. Currently this is more of an issue for cyclists where in some cases they have to transverse a station to locate inconveniently placed bike parking.

Between 2010 and 2015 the UK saw a 40% increase in the number of cycle-train trips, and this is partly related to investments in station cycle parking. Cycle parking provision at UK train stations more than trebled over that period, to 77,000 spaces, and the number of train journeys involving a cycle being parked at a station almost doubled. Despite these improvements, there is still a long way to go. On average there are 30 cycle spaces per station in the UK compared to 1,220 per station in the Netherlands [52].

On arrival at a station, the cycle parking should be easy to find (with good signage) and conveniently located. At larger stations with multiple entrances, some informal parking should be provided near each entrance, so that cycles can be parked before entering the station. This is particularly relevant for very large stations where people may travel for the station's services (shops, restaurants) rather than train trips. In the case of more formal managed facilities such as bike sheds, these should be as close as possible to the ticket office or gates.

Convenient and easy bikeparking, Dordrecht
© Dutch Cycling Embassy

Helmond Station
Named the Cleanest Station in the Netherlands in 2014 and won the Brunel Award for railway-related architecture. The bicycle parking has a green roof and the modular design means it can be expanded as and when demand increases. A planted square provides an attractive entrance [53].

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Safe and secure cycle parking

Cycle parking

Cycle parking should be safe to use, without causing a risk of injury either due to the need for awkward lifting movements or bikes falling from double-decked stands. The parking must also be sheltered and secure; either guarded, monitored by station staff or covered by CCTV surveillance.

The parking capacity should also be sufficient for the demand or desired demand. Transport for London recommends that additional cycle parking should be provided when the existing parking is regularly reaching 80% utilisation. In order to know where parking is reaching 80% utilisation, the use needs to be regularly monitored, recorded and reviewed [47]. Where cycles are parked unofficially on railings and lamp posts, this is an indication that there is either not enough cycle parking, or the parking is inconveniently located. This has been seen in the UK. At Kingston Train station bicycles continued to be attached to railings, while the 'official' cycle parking remained largely unused because of poor placement [47].

Dense and secure bikeparking, Utrecht Centraal
© Dutch Cycling Embassy

Bicycle storage for baskets & crates
© Falco [57]

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Attractive cycle parking at multiple entrances

The Netherlands is well known for their exceptional safe and expansive cycle parking. Half of the daily 1.3 million train passengers take their bicycle to the station. Around 15% cycle to their final destination after the train journey. Currently ProRail are building 20,000 bicycle parking spaces per year [58].

One example is the recently opened bike shed in Tilburg which has space for 3,400 bicycles and 200 shared bikes [59]. The shared bikes are owned and run by the national rail operator with integrated payment.
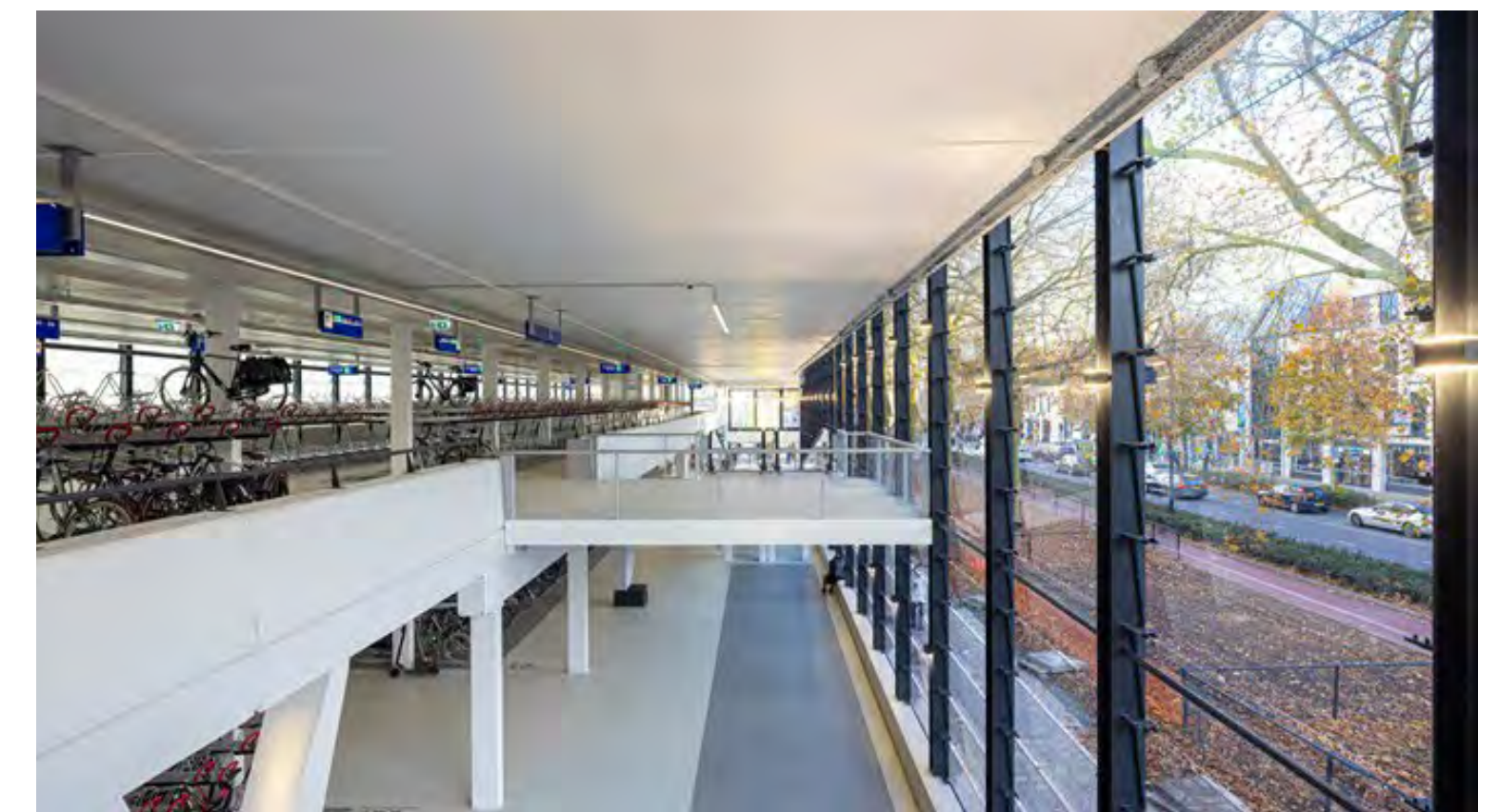
The shed has been designed to the Dutch 'Fietsparkeur' standard[60], and includes the following features:

– Automated check in and out (linked to public transport card)

– Open and guarded 24hrs

– Bicycle and service shop for repairs and accessories

– Moving bicycle escalator

– Green roof for drainage and climate control

– Natural light (glass) minimizes the use of artificial lighting

Across the Netherlands, bike sheds have a digital system which recognizes where there are available parking locations, helping travellers to easily find a free space at the station [61].

– The smart digital bicycle parking system detects all sizes of parked bicycles.

– The system keeps track of when a bicycle has been placed, so that the bicycle parking manager can remove bicycles that have been parked for too long - 'orphaned bicycles'.

NS (the Dutch passenger railway operator) are not just facilitating cycle parking for traditional bikes. 15-20% of bicycles are 'deviating': with high handlebars, wide panniers and child seats. They are now piloting a range of solutions for parking deviating bicycles. Many stations already offer customized solutions for 'outdoor models' including tricycles and cargo bikes.

Tilburg Bike Shed
© ProRail [59]

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Creative solutions to promote access by bike

Underground cycle parking

Underground cycle parking is becoming popular in Asia. Japan's system is linked with a transport card and takes eight seconds to park a bike[62]. This protects bikes from theft and poor weather and is an effective way to introduce cycle parking with little available above ground space.

Underground bike parking in Japan
© Arup

Bikesharing

Bikesharing is a popular solution for train stations internationally. Instead of taking bikes on trains - which is usually prohibited in peak hours or requires pre-booking - passengers can pick up a shared bike at the station for their onward journey.

One of the main reasons bike sharing is so popular in the Netherlands is that it saves time compared to other modes. Part of the reason for that is that it is available at the station with the same ticketing system, so there is no need to exit the immediate station environment and go through the logistics of signing up for an additional ticketing platform. The OV-fiets public transport bike scheme has been taken over by NS and is very successful, growing at 15% per month and doubling every year.

Some operators in the UK have begun to implement cycle hire/bike-sharing, but this is not uniform or the norm. The Bike & Go cycle hire scheme is a national innovation, jointly developed by Merseyrail, Northern Rail and Greater Anglia [63]. Stirling has set up a Cycle Hub at the train station. This is a hub where expert staff and locals share their knowledge of cycle routes, cycle groups and networks in and around Stirling. Wall maps are available to help with route planning and there are route maps to take away. Since September cycle hire has also been available from the Stirling Hub [64]. Brompton (famous for their foldable bicycles) are now offering bicycle hire at several stations, particularly targeting the London commuting belt.

Amsterdam Zuid NS bikesharing
© Dutch Cycling Embassy

The Station

Adapting stations to their setting

Placemaking

Passenger hubs should be a continuation of the public realm, town centre and/or high street, promoting permeability, but clearly identifiable in the landscape.

The current design of many stations is typically inward facing, often complicated by railway lines, harsh fencing and gates that can sever the station from its surroundings. Built-up and paved environments can be made more friendly with trees, shrubs, perennials and hedges. This can shield from wind, provide shade and encourage pollinators in an era of biodiversity decline [22]. ProRail's Platform Programme has consulted with ecological experts and local communities to ensure the right selection of plants for the water levels, soil type and local species and resulted in a range of beautifully planted stations in keeping with their surroundings and local context [65].

Integration with the natural environment through sensitive planting is becoming more popular. Aside from the visual appeal of planting and placemaking around stations, there are benefits for biodiversity and climate resilience. Public art and lighting can also improve the quality of space in and around the stations.

In the north of the Netherlands a €1 billion programme to improve rail facilities has resulted in the improvements to Coevorden Station which includes a planted entrance and nearby roundabouts, new ramps and a clean and bridge underpass for pedestrians [66].

Placemaking around stations also have benefits for the wider area. Placemaking encourages walking to, from and around stations, and higher footfall around stations and along pedestrian routes enhances the sense of safety, encouraging the use of train travel in off-peak hours.

Other place-enhancing interventions include dynamic lighting and public art; both of which can make the place more used, which in turns feels safer for people. It is important that any interventions proposed include provision for all ages to make sure everybody feels like they belong.

Coevorden station
© Bicycle Dutch

Placemaking and planting around Coevorden station
© Bicycle Dutch

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Maximising the value of stations and their surroundings

The value of space

In some cases there is even more potential for placemaking and the installation of large Dutch-style bicycle sheds if car parking space is reduced, and train maintenance depots are moved out of prime urban land.

East Japan Railway has adopted this approach of relocating lower-value activities. At Shinagawa, a train depot was moved further out of the city to release land for development. This is an approach that could be further considered in the UK where there is an urgent need for housing, and housing located near to stations promotes sustainable mobility patterns [67].

TfL owns 5,700 acres of land, owns or manages 400 stations, 61 car parks and many other surplus or underused sites. Rather than selling land, TfL has chosen 13 partners, including house builders Barratt, Berkeley, Taylor Wimpey and Redrow, with which to develop sites in joint ventures.

The pedestrian southern entrance to Leeds station (opened in January 2016), was built to serve new office and hotel developments around Bridgewater Place. The eye-catching entrance to the £20 million scheme is attractively sited overlooking a canal and is expected to relieve pedestrian congestion at the main entrance by giving an alternative access point to 20% of station users. The new southern entrance is seen as key to enabling successful regeneration of the surrounding area [68].

Tilburg LocHal

An urban mixed use 'living room' in a previous Dutch Railways rail shed used as a local library, community centre and co-working space.
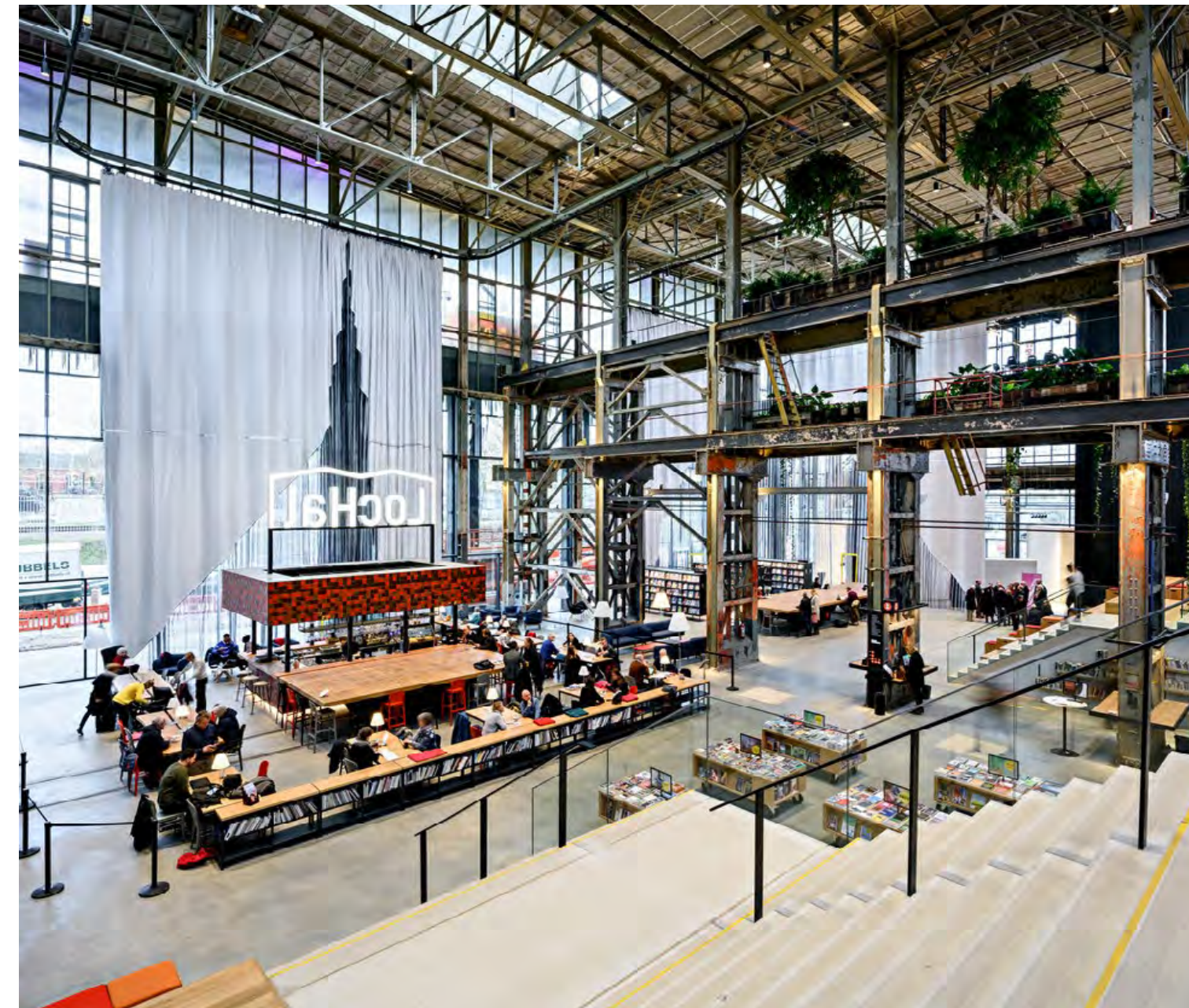
© Arjen Veldt Fotografie [69]

Holbeck Urban Village

A regenerated mixed-use area near Leeds Railway Station.

© Leeds City Council [70]

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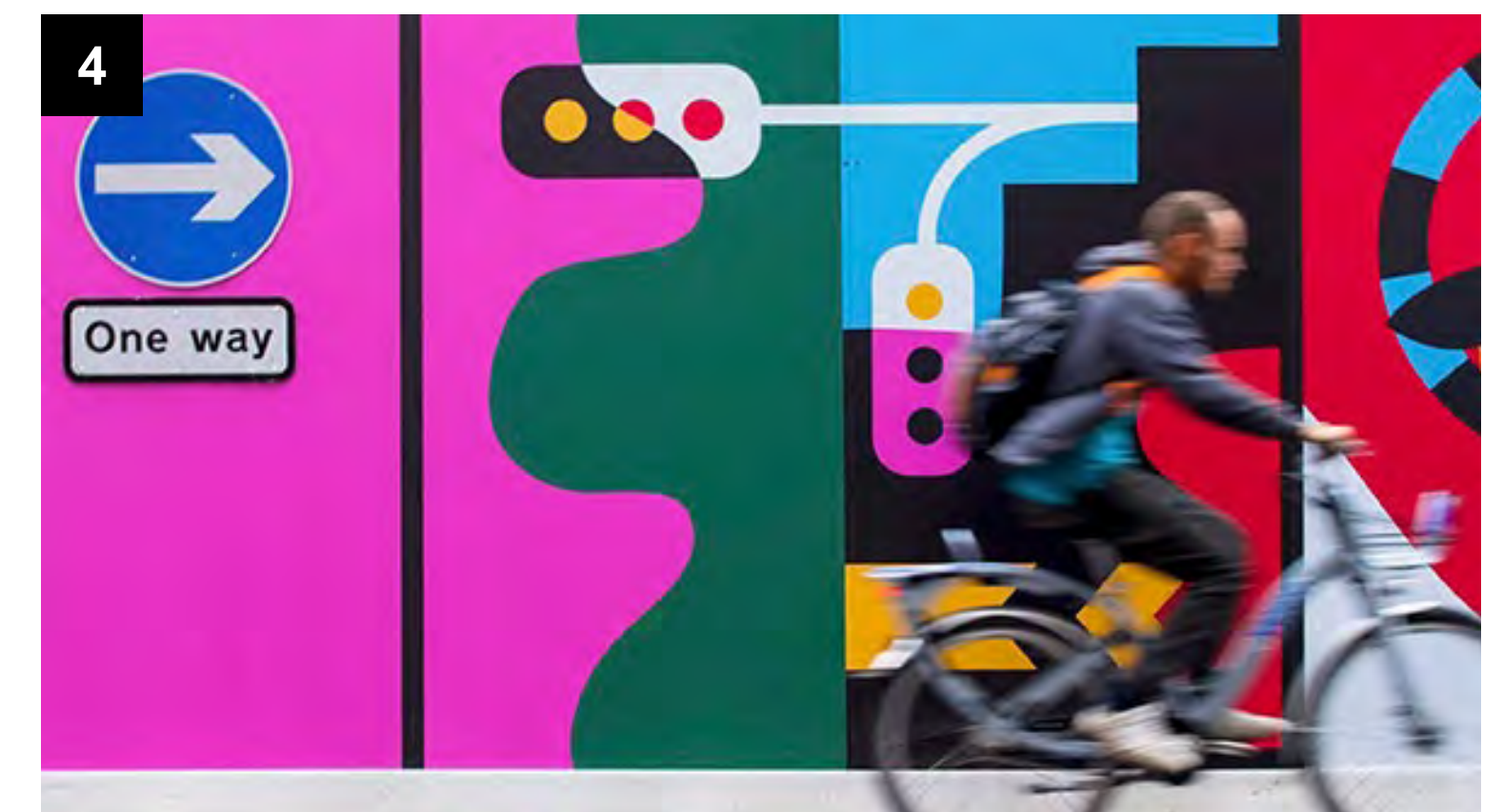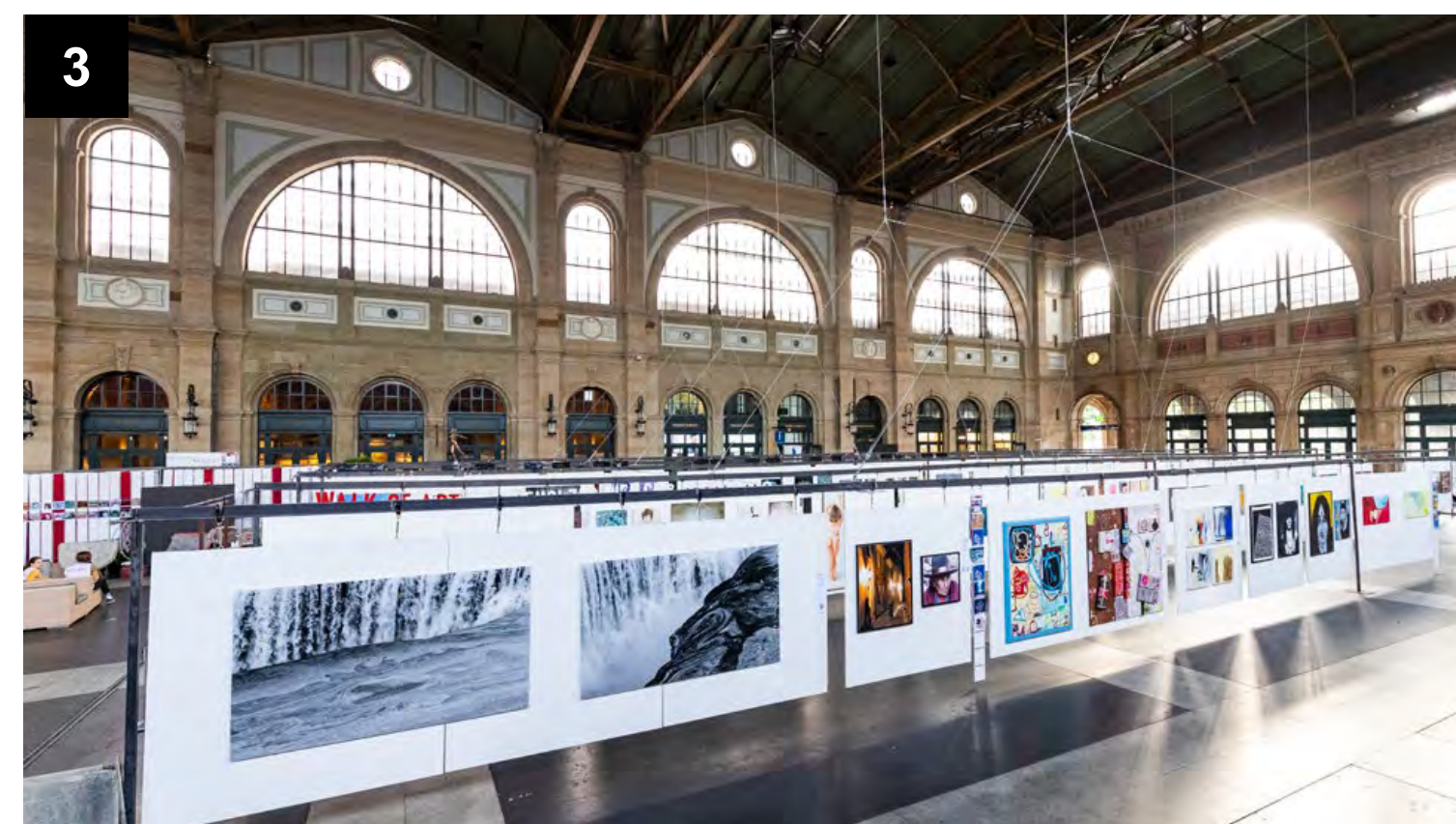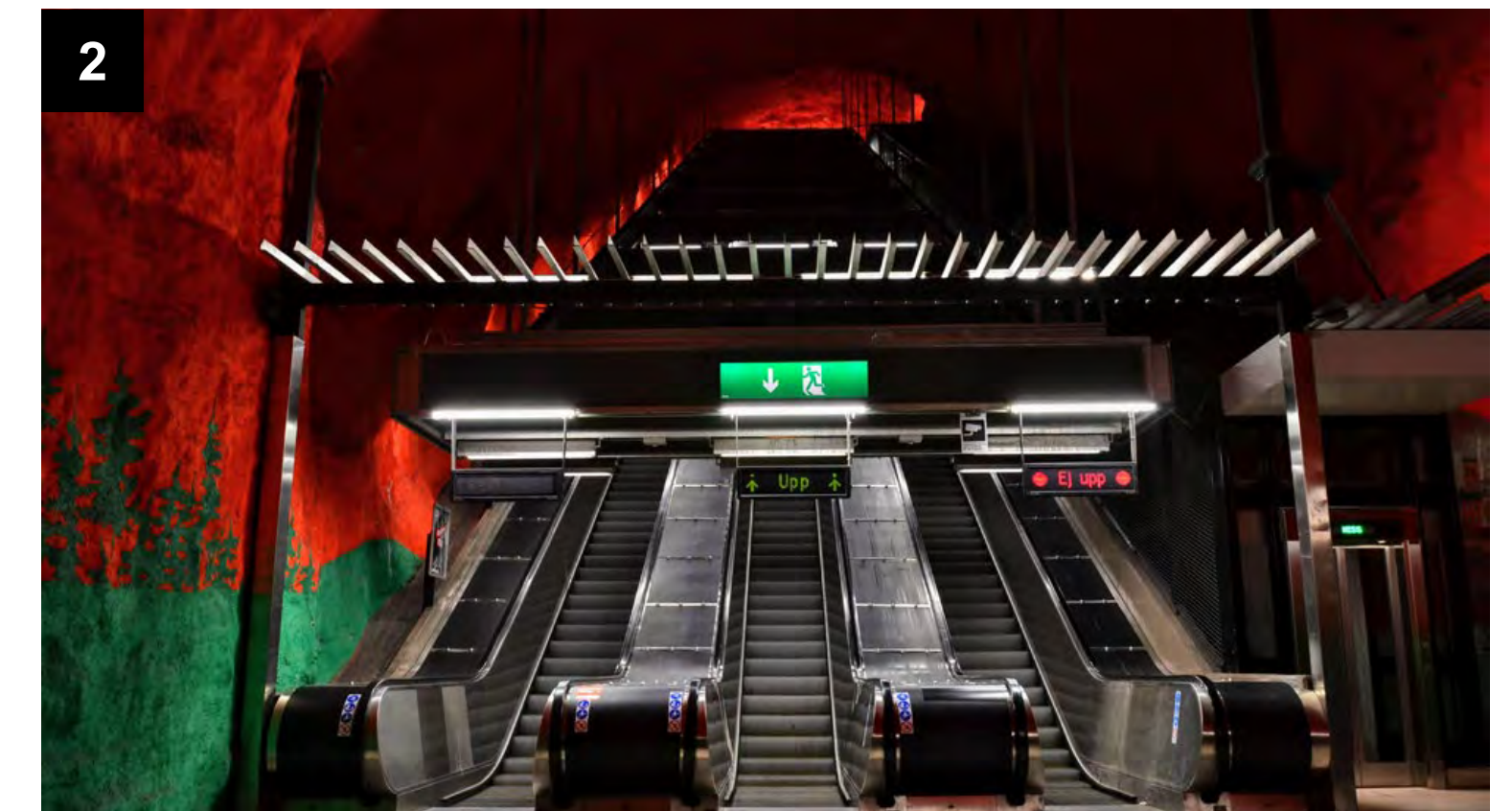# Integrating art and design within stations

Engaging spaces

Placemaking can occur within the stations, for example through the introduction of art or cultural exhibitions. These exhibitions can provide education for visitors, and interest to regular users, and can even be revenue generating (e.g. Waterloo Station's film-themed annual makeover).

There are several examples around the world where art and culture has been embedded into public transport networks to make for more exciting, lively spaces.

1. The University of Leicester School of Museum Studies took the touring 100 Images of Migration exhibition to Leicester train station [71].

2. The Stockholm metro system has been called the world's longest art exhibit because 90 of its stations are decorated with artwork [72].

3. SWISSARTEXPO offers artists the opportunity to present their original works inside Zurich's main railway station. With over 80,000 visitors daily, it is one of the most visited halls in Europe [73].

4. Glasgow Queen Street Station received a bright makeover during the redevelopment by local artist Gabriella Marcella Di Tano [74].

The use of colour should not make navigation challenging for those with disabilities - particularly at crossings - or make the built environment less safe and inclusive. Equality Impact Assessments are useful for testing the appropriateness of art and cultural installations.
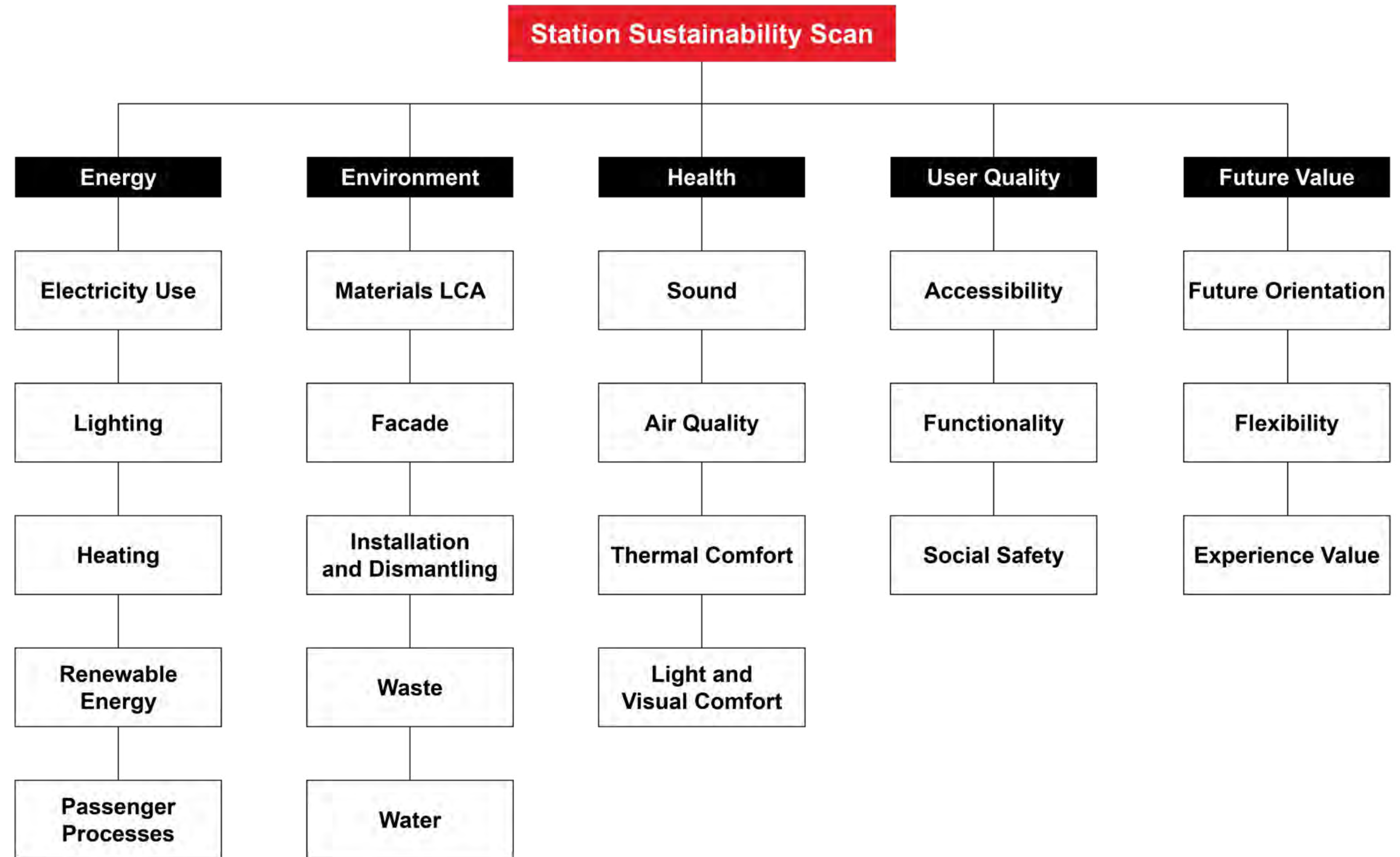
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Sustainable stations

Station Sustainability Scan: ProRail, NS Stations and W/E Adviseurs have developed a tool to examine stations based on five themes: Energy, Environment, Health, User Quality and Future Value.

This tool has been used to calculate a baseline measurement for over 100 stations and improvements can be targeted where the scores need to be improved. The aim is to achieve a score of 7.5 or higher for new construction projects and work towards raising the national average from 6.0 to 7.0.

Station Sustainability Scan

Energy	Environment	Health	User Quality	Future Value
Electricity Use	Materials LCA	Sound	Accessibility	Future Orientation
Lighting	Facade	Air Quality	Functionality	Flexibility
Heating	Installation and Dismantling	Thermal Comfort	Social Safety	Experience Value
Renewable Energy	Waste	Light and Visual Comfort		
Passenger Processes	Water			

Dutch Station Sustainability Scan
Adapted from Spoorbleed [72]

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Inclusive stations

Nobody should have to change trains, travel to a different station or take a diversion to reach the correct platform as a result of station inaccessibility. There are over 14 million people in Great Britain with some form of disability [76] and therefore, information on station accessibility needs to be freely available. If there are station -specific parking areas, then adapted parking spaces must also be available. In the UK there is guidance to provide one space for each disabled employee plus 5% of the total car park capacity [77] .

In the UK DfT Station Accessibility Code of Practice there is accessibility information on car parking facilities and local transport interchanges (bus stops and pick-up/drop-off zones), however, there is no specific guidance for walking or cycling. The only discussion around pedestrian provision is related to minimising conflict and collision risk between pedestrians and cars in car parks.

Accessible stations are more popular: passenger numbers can increased by 20% with step-free access.

Hidden Disabilities Sunflower Scheme
Sunflower lanyards are helping passengers with hidden disabilities. They enable passengers to discretely show staff they might need extra help while travelling and moving through the station [78].

In 2019, the UK rail industry launched an interactive access map. Now passengers can easily find out about station accessibility, helping people to feel more confident using the train . Passengers can book assistance for any train journey, with one number. Between summer 2017 and August 2019 more than 45,000 people called or texted to organise help at the station, a ramp to board or to be met at the end of a journey. An app is being developed to cater for assistance booking.

Routes around and through the station need to be free of obstacles such as café tables and A-boards so that wheelchair users can easily navigate to and from platforms. Currently in the UK not all stations are required to have a lift or ramp to provide a step-free route. Stations that have less than 1,000 passengers per day do not need to provide a step-free route provided that another station within 50km on the same route has step-free access.

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Digital stations

Many aspects of the built environment are undergoing a digital transition. The same can be said for the transport and rail sectors, which are embracing technology to improve accessibility, reliability and the overall customer experience.

Digital ticketing

By reducing conventional pinch-points from multiple (ticket purchase, collection, gate line) to zero, boundaries between the functional station space and retail, amenity and public spaces beyond becomes invisible [79]. In 2016, 70% of UK train tickets were purchased at the station, but advances in digital ticketing are reducing the time and space needed to buy a ticket onsite, as well as the anxiety related to finding and crossing gate lines during short transfers [80]. Digital ticketing (e.g. QR and barcodes) makes the station experience more homogenous, reducing the need to study station plans to determine where to buy and use tickets. However, there should always be the option to purchase tickets in-person to prevent digital exclusion, and cater for those without or uncomfortable using smartphones and apps.
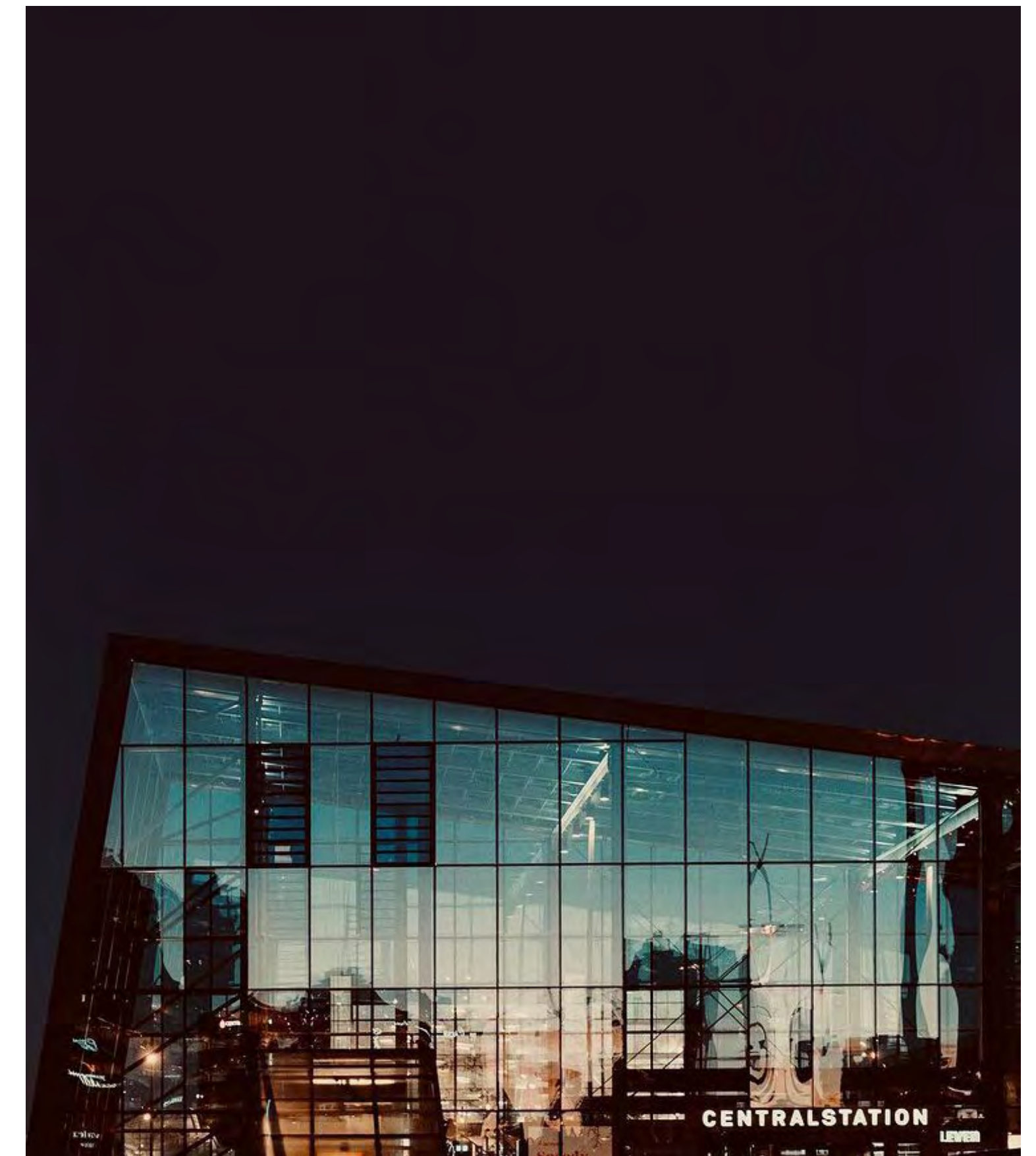
Digital ticketing can reduce the need for physical gates to check tickets. In Denmark, passengers are able to walk straight onto trains from the station exterior without the need to pass through gates. This also has the potential to reduce queuing and crowding in stations.

Passenger data

The digital transition is enabling station and railway operators to collect more detailed data and who is using the network and how. This can be used to inform future improvement programmes and improve relationships between operators and customers. In the case of active-train users, operators can learn about cycle parking demand, access and egress modes and walking times through stations. This can all be used to improve multimodality.

Digital reservations

Many Train Operating Companies (TOCs) are now using digital reservations to book and assign seats. This improves transition, as passengers do not have to walk through carriages - often with luggage - to locate an empty seat, but go straight to their dedicated space. Knowing there will be a seat improves the accessibility of the rail experience, reduces the likelihood of passenger conflict and reduces stress.

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New tools to aid navigation

The company NaviLens has introduced a mobile phone application to improve the experience of using public transport for visually impaired users. The app uses NaviLens codes (simplified QR codes) that can be scanned from far away (12 times further than QR and barcodes). These codes dictate information about public transport stops and stations (e.g. the location of lifts, platforms, escalators and information desks) and aid navigation around crowded and unfamiliar urban interchanges. The app has been used in the crowded New York Metro system where there are over 100 codes to help visually impaired people to be more independent in new spaces and avoid any discrepancies between the information they and other users receive. The information is read to users through headphones and is available in 24 languages, making the app also useful to those who are not native English speakers [81].

GoMedia has received DfT funding in the UK to develop and implement a similar accessibility service to give personalised on-board announcements on train journeys and aid independent and stress-free navigation to platforms [82].

Connected stations

In China, Huawei launched the world's first 5G train station in Shanghai Hongqiao in 2019. Passengers are able to access data much faster, which is particularly useful when researching onward journeys and station facilities[83].
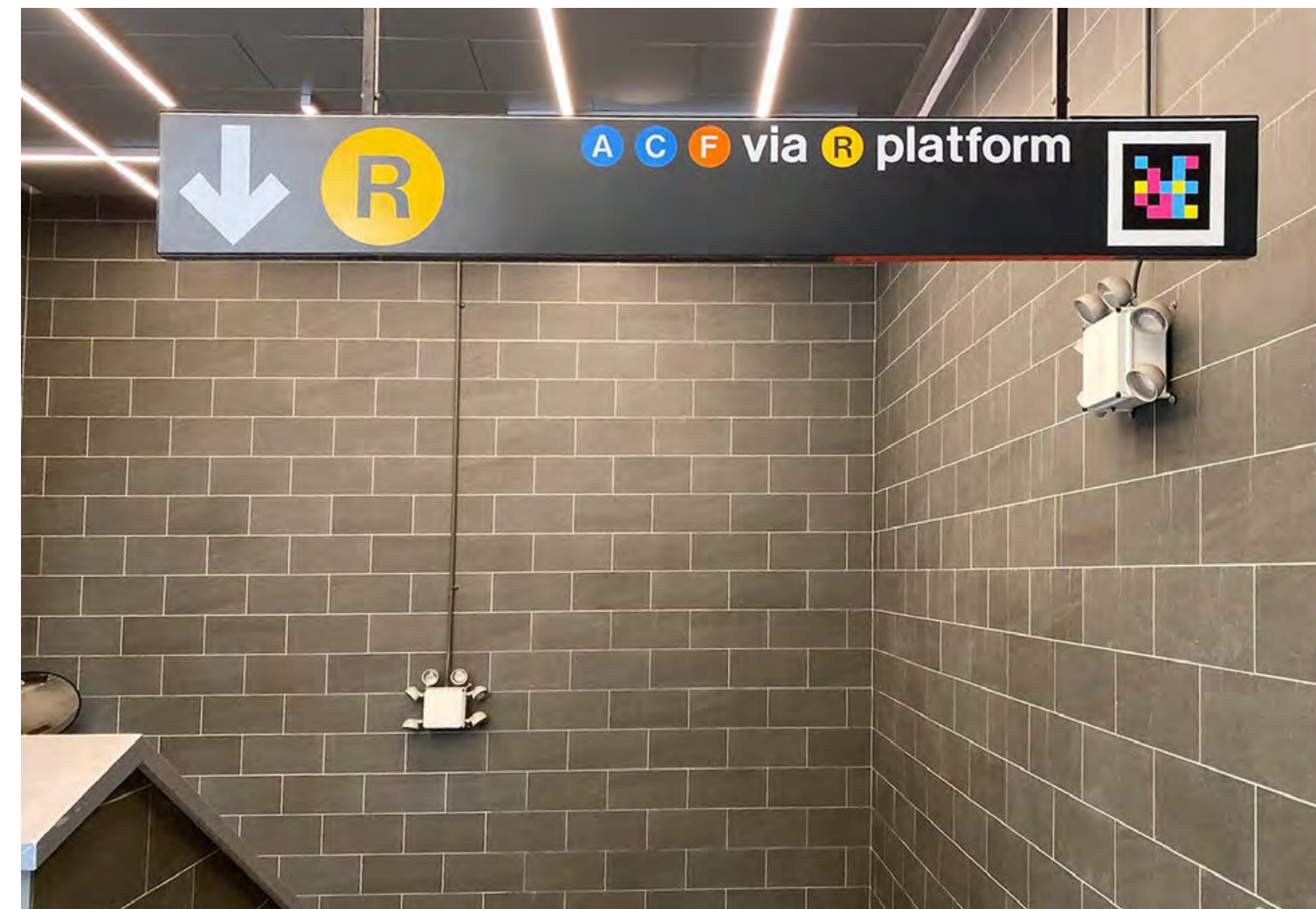
NaviLens code guiding users to New York subway platforms
© NaviLens
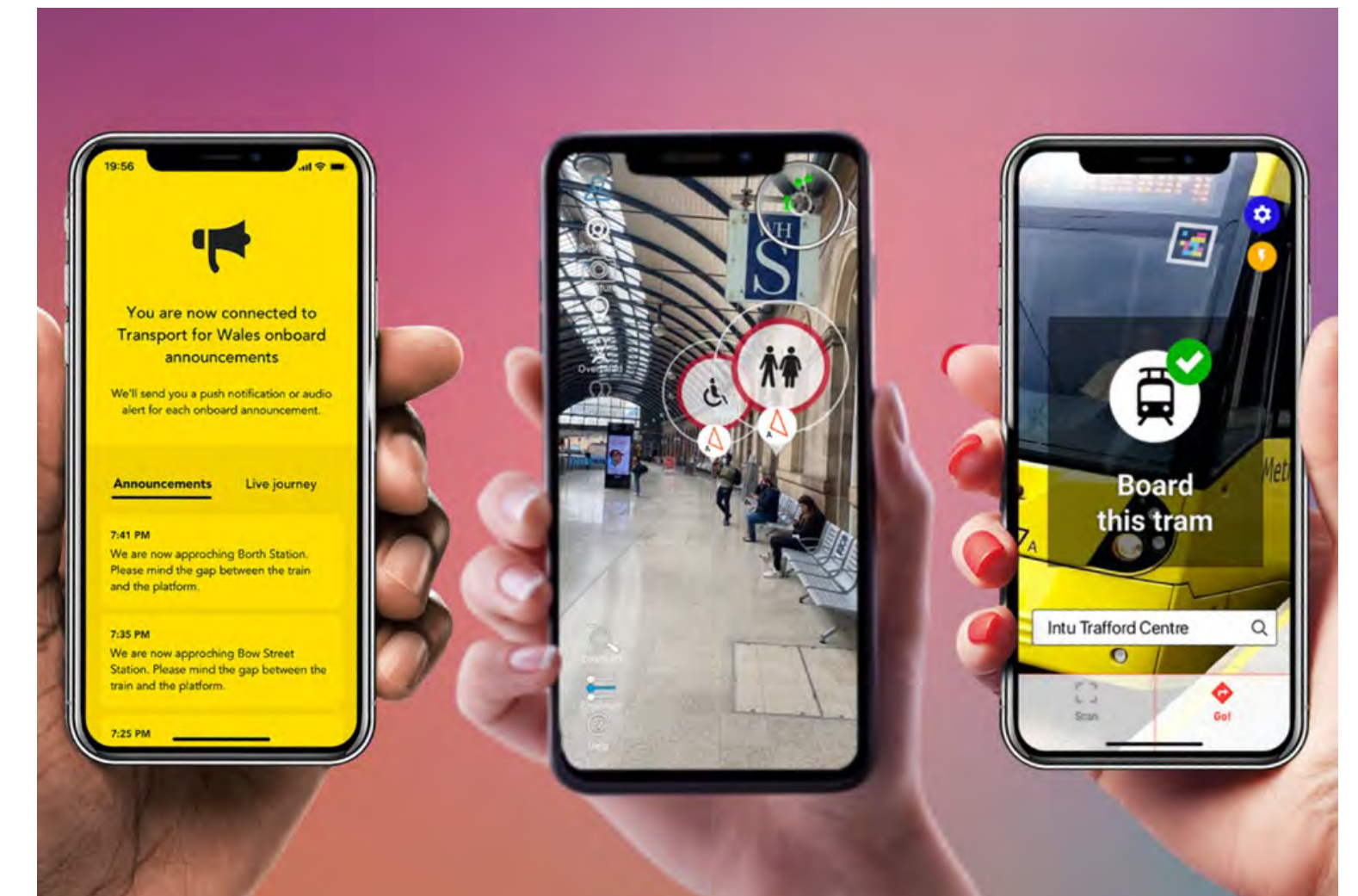
GoMedia developing digital solutions for the visually and hearing-impaired for the DfT
© GoMedia

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Stations as mobility hubs

Local authorities around the world are investigating the opportunities for Mobility Hubs.

A mobility hub is a place where people can switch from one mode of transport to another with convenient facilities designed for a low-carbon society [81].

Many train stations are already to some extent mobility hubs
Bus and tram routes are designed to drop off and pick up customers around train stations. Stations in the Netherlands and Sweden are already ahead of the curve, with many offering seamless, and extensive bike parking and bikesharing, alongside public transport integration.

Stations are a good starting point for a mobility hub
There are already usually several modes meeting here, particularly if they are in city/town centre locations. The stations can adapt over time to include further modes, such as e-scooters, electric carsharing and e-bikes.

Each station will be at a different level of integration
Some will already provide access to many additional modes besides the train - but in order to further encourage multimodality, one simple ticketing and information system with consistent branding is required. A user will not want to purchase individual tickets for a shared bike ride to a station, train journey, and e-scooter ride to final destination. Seamless end-to-end ticketing with one operator, and one app in the Netherlands is helping to facilitate active-train journeys. Read more about the NS-app.

Mobility hubs can include other features, less common to train stations:

– E-bike charging;

– Bike maintenance stores;

– Co-working spaces;

– Delivery lockers;

– Pop up food trucks;

– Micro playgrounds, and

– Community gardens.

Read more about Future Mobility Hubs.

E-bike solar charging in Delft
© Dutch Cycling Embassy

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Consider wider catchments and access by e-bike

People travel door-to-door, not station-to-station, so the network must facilitate this. Typically, the focus is on the immediate area around the train station (e.g. under 1 km). However, greater distances between 3-5km should be considered. The average cycle trip length in the Netherlands is 3km, which supports the need to evaluate the active travel network beyond the station's immediate surroundings. ComoUK's bike share study found that most users (37%) were using bikesharing for trips up to 2 miles (3km) and and 32% used them for 3-4 miles (4.8-6.4km), suggesting that wider catchments need to be considered in active station planning [85].
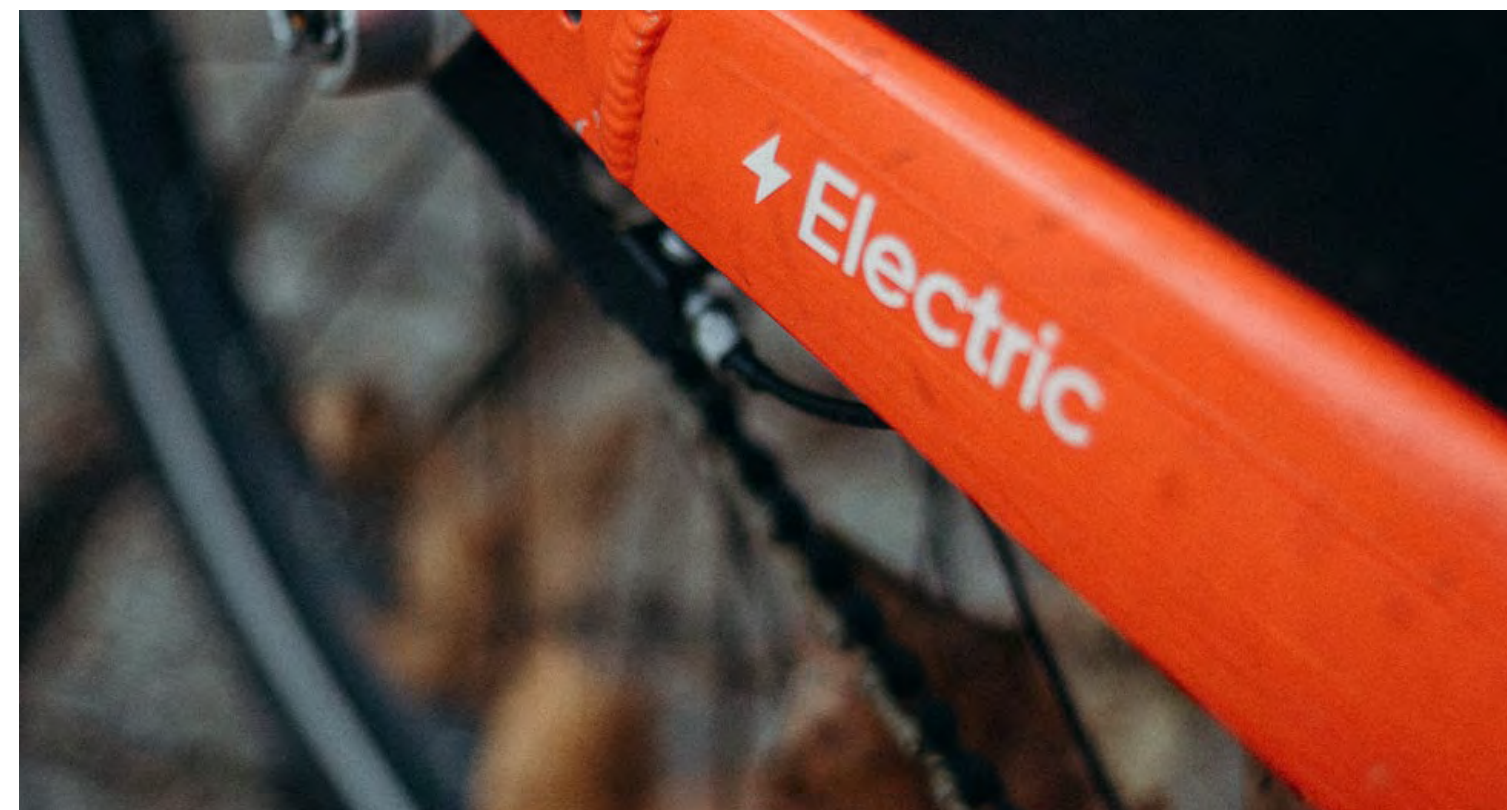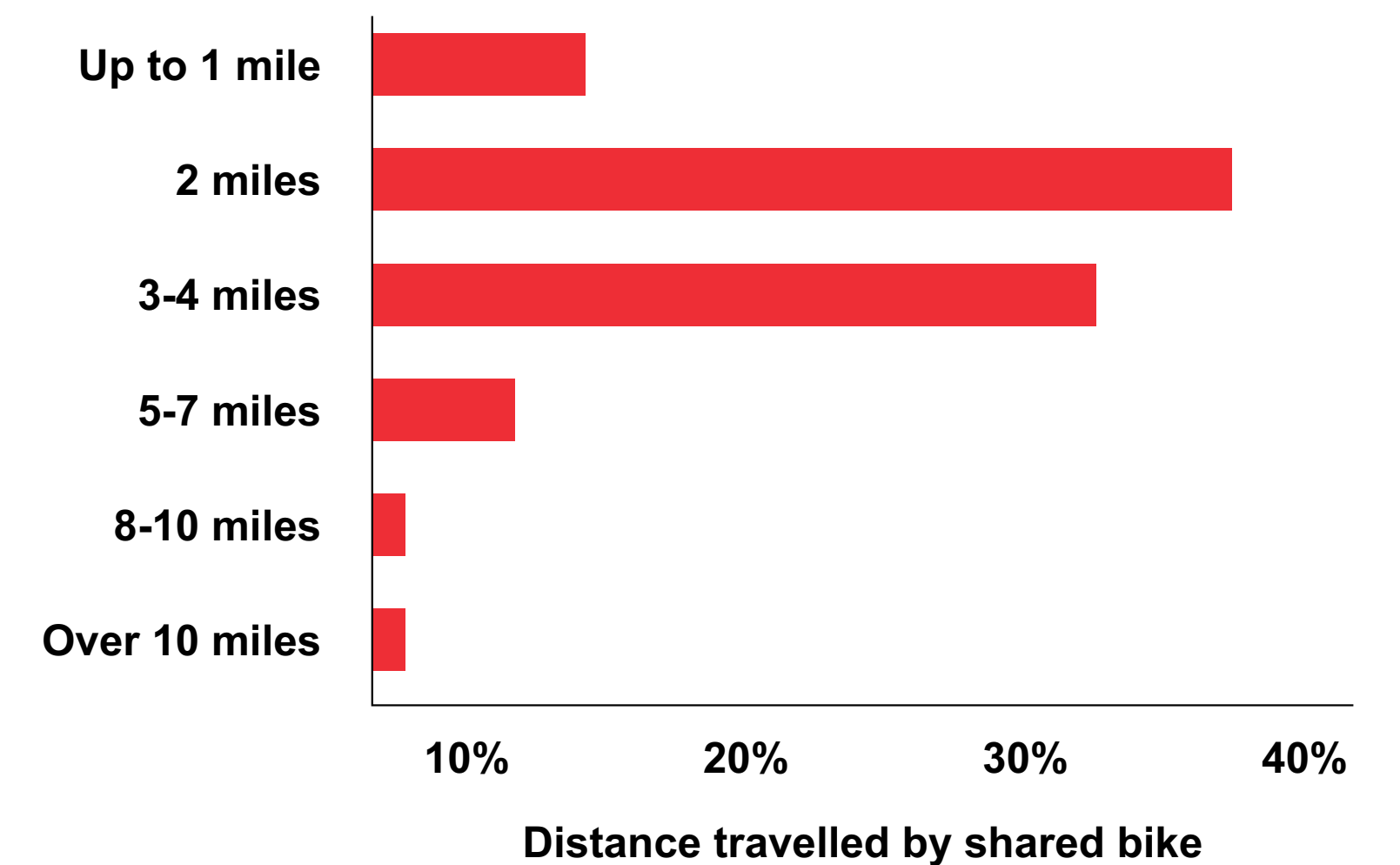
Stations that are centrally located can be walked or cycled to by many - even those with a car - because it is more convenient, cheaper and has a range of additional benefits. In total, 66% of bike-train users in the Netherlands have car access but prefer to not use it. In the Netherlands, 21% of bike-train trips replace car trips, suggesting great potential for mode shift if active network standards facilitate combined trips [83]. On arrival at train stations, travellers should be able to immediately access walking and cycling networks and use these to complete their trips to work, education, or leisure destinations.

E-bikes on the rise

Over the course of the pandemic, we have seen enormous growth in the uptake of e-bikes, with 30-40% growth rates in many European countries [84]. This further supports the need to consider wider networks, since greater distances are typically covered by e-bikes.

In some cases e-bikes are a more attractive option than conventional bikes, extending the possibilities for active-train trips. E-bikes can help users to cover greater distances and tackle steeper gradients. However, a study of e-bike use in the UK found that the availability of separate cycling infrastructure was a barrier to greater uptake [88].

E-bikes are more expensive than traditional bikes, making secure, covered bike parking even more important when encouraging e-bike users to cycle to train stations.

© Cottonbro

Distance travelled by shared bike

(Bar chart showing distance categories:)
- Up to 1 mile
- 2 miles
- 3-4 miles
- 5-7 miles
- 8-10 miles
- Over 10 miles

(x-axis: 10% 20% 30% 40%)

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Make the local environment walkable

Aside from the station improvements, interventions can be applied to the surrounding environment to make it more suitable and attractive for everyone to walk.

Routes must be safe, useful and interesting to make sure that people actually enjoy walking and not just see it as a necessity; which in turn will prompt them to walk more.

Some of the ways walks can be improved are:

– Routes should be as direct as possible (preference for straight routes rather than diversions);

– Permeable (with multiple paths connecting together);

– Well signposted;

– Interesting and unique (so that people don't see walking as a 'chore'), by passing places of interest or introducing feature lighting or public art;

– Routes should, where possible pass through a mixture of uses to make sure people can run errands on their walks from and to the stations;

– Well lit to improve safety - but lit in a way that respects the natural environment;

– Tree-lined and planted to provide shade and buffer air and noise pollution. However, this must be done in moderation to make sure a route is overlooked to encourage more underrepresented groups of people to walk (especially women and people from ethic minority backgrounds);

– Have numerous safe crossing points along desire lines;

– Continuous, with bridges where necessary (whilst making sure that the level differences are kept to a minimum for people with movement difficulties);

– Have a range of essential services (e.g. waste bins and benches at regular intervals);

– Be accessible with smooth surfaces, adequate widths, drop curbs, tactile paving at crossings.

Copenhagen (right) delivered almost four times more car-free spaces from 1968 - 1996 and the result was almost four times more physical activity [89]. The gradual reduction of on-street car parking and the extension of the metro system has also contributed to more walking and multi-modal trips.

© Kai Pilger

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Wayfinding strategies to connect station users to walking networks

Walking improvements continued

– Be well-maintained (swept of leaves, ice, snow and debris, resurfaced when necessary);

– Segregated and buffered from other modes;

– Free of unnecessary clutter;

– Sufficiently wide to increase usability for mobility scooters, pushchairs, wheelchairs, as well as to enable people to walk alongside each other and converse;

– Include pedestrianised and/or living streets, particularly in areas with high pedestrian flows;

– Appealing and attractive with planting, art, parklets, and active storefronts;

– Resilient and connected to nature - extracting value from local greenways and blueways; and

– Varied to cater for recreational walkers and runners, as well as everyday utility trips.

Legible London, London's citywide wayfinding system, is the world's largest wayfinding system. The system has been designed to integrate all of London's transport modes. Mapping public transport stops, cycle superhighways and cycle hire docks, the system facilitates multi-modal trips. The bright yellow stripe on the top of the signs helps them stand out to residents and visitors amongst the urban landscape. The scheme has been responsible for a 5% increase in walking across the city [90].

© Arup

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Consider walking and cycling as separate but related modes

It is also vital that walking routes integrate well with cycling routes, and that one mode is not impeding the other. After all, most cyclists will also walk as part of their journey. This can be done by the use of shared spaces however, where those are employed, it is important that the environment is still safe and comfortable for all, particularly as walking and wheeling are at the top of the transport hierarchy. Enrique Peñalosa (the former Mayor of Bogotá) aid that "if a bike lane isn't safe for an eight-year-old, it's not really a bike lane" and it is important to remember that this should apply for walking paths as well.

It is only by having high-quality walking routes and cycling paths around the stations, which link to high-quality public transport provision, that we will make sure they're contributing to the modal shift away from private vehicles. It is therefore important to make sure that all of the individual elements (walking and cycling paths, train stations, public transport provision) work well both individually and when taken together.

Case study

Tilburg

Has trialled Dynniq's CrossWalk mobile application which extends the green time at traffic signals when elderly or disabled users approach the lights, giving them greater confidence in crossing the road. The service has been expanded to cycling. The app can help traffic signal systems detect groups of cyclists - including school cycling 'buses' - and ensure they cross the road together, aiding more comfortable, social and safe cycling, especially for journeys to school [91].

© Pille Kirsi

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Create environments suitable for all types of cyclists

Network Rail and Cycling UK have recently partnered together on a new programme to explore the cycle-train combination as a recent survey found that a fifth of survey respondents say they're considering cycling for their journey to work [92]. Despite many wanting to cycle for parts of their journey, there are several key barriers revealed by the study:

– 49% are worried about cycling on busy roads (which increases to 55% for Londoners);

– 22% are concerned their bike will get stolen or damaged, and

– 15% are worried there won't be enough available bike storage at or near their place of work.

This indicates that bike parking needs addressing across the UK, as well as the quality of the cycling networks around stations.

The cycle-train combination can involve cycles being parked at one or both ends of the journey. Another possibility is using a hired pedal cycle at one end of the journey, potentially from a public hire-bike scheme (such as London's 'Santander Cycles' or The Dutch OV-fiets system). Regardless of whether private or shared bikes are used, high quality networks around stations are essential.

Enabling passengers to cycle to the station increases the catchment area for rail services sixteen-fold, compared with walking. This can make a crucial difference to the viability of rail services, especially in rural locations. It can also reduce the substantial capital and space costs of providing station car parking.

In the Netherlands, 42% of train trips involve cycling at the 'home end' of the journey while 11% of train trips are completed by bike at the non-home end. In the UK just 2.8% of train trips in Britain in 2015 also involved cycling (48 million cycle-train trips out of a total of 1.72 billion train trips) [55]. Due to the different trends in cycle behaviour at home and destination ends of trips, different strategies should be considered for different stations.

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Consider the context of the station when designing a cycle parking strategy

Work-end stations

These are stations where the surrounding land use is predominantly retail and commercial. These are where people travel to for work and education and to access leisure facilities such as cinemas, theatres, large shopping centres or streets and restaurants. The land use will typically be medium-high to high density and therefore many may wish to walk to their final destination from the station. The routes taken on arrival are likely to be predictable - to these trip attractors - which can form the basis of a bike-sharing scheme. Docks can be placed at regular intervals at key locations, particularly those beyond the walking catchment. The focus for cycling routes here should be on separating cycle paths as town and city centres can be busy with other users - bus, tram and pedestrians. There should also be numerous crossings to enable cyclists to access their final destinations safely.

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Consider the context of the station when designing a cycle parking strategy

Home-end stations

These are stations where the surrounding land use is primarily residential. Users will travel to the station and then take an onward journey to access services in larger towns and cities. These stations should focus on expanding and improving the cycling catchment to enable a greater number of passengers to access the station. The bike parking strategy should focus on providing for the local population and the diverse range of bicycles they may bring to the station (cargo bikes, bikes with child seats, adapted bikes). Good security measures should be implemented so that passengers feel their bike will be safe from theft or damages whilst they are on the train or at their destination. These stations could consider integrating facilities for pumping tyres or routine bike maintenance. The routes to and from these stations through the residential areas should be high quality and well-lit to encourage year round use.

Rural home end stations

These will have similar requirements to home-end stations, but should also consider linkages with recreational cycle trails and popular outdoor areas and nature reserves. With more sparse housing, planners should consider wider catchments, suitable for e-bike trips.

Mixed stations

These are stations such as Reading and Cambridge where the proportion of in-commuting and out -commuting by train is roughly similar. These stations will require a hybrid approach to provide for those travelling to the stations from residential areas, and those with onward journeys through retail and commercial land.

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Cycle design principles: The CROW manual

The Dutch CROW Bicycle Design manual is based around five key principles for bicycle infrastructure that can be transferred to almost any context [90].

1. Cohesion

Being able to cycle from anywhere, to anywhere.

Citizens should be able to travel from any location by bicycle - or with the bicycle as part of a multimodal trip - without facing gaps or obstacles. The network should enable door-to-door transport with no sudden stops or need to dismount. In many UK towns and cities we see cycle highways or recreational routes along popular leisure facilities (e.g. canals). What is often missing is an extensive, cohesive network.

2. Directness

Cycle routes should be direct with minimal detours.

Cycle routes should be as direct as possible, following straight lines that are fast and competitive with other modes. Cyclists should not be forced to take slower, indirect routes.
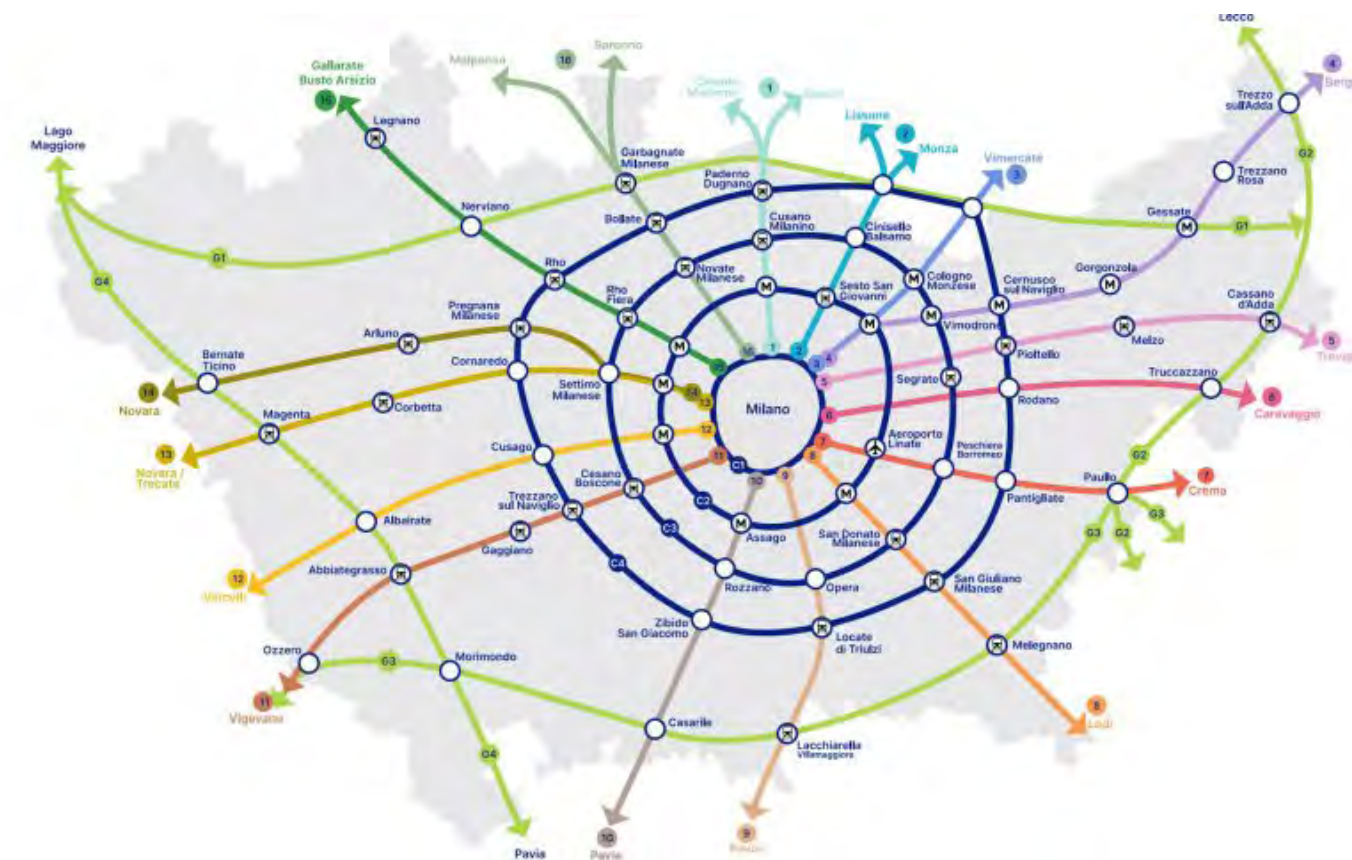
Cambio
Milan's new bicycle plan for an extensive, cohesive metropolitan network with 4 circular, 16 radial and 4 greenways [94].

Cycling network
Copenhagen's cycling network includes direct routes between key locations to avoid any delays for cyclists, particularly in peak periods [95].

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Cycle design principles: The CROW manual

3. Safety

Improve personal and road safety:
Cyclists should feel safe in terms of road safety, but also in terms of exposure to pollutants, noise and stress. As a general rule it is recommend that networks are planned to avoid differences in speed and mass. Cyclists should be separated from cars and vans particularly where there is a great difference in speed. If this is not possible, vehicular speeds should be reduced (e.g. 20mph zones). Where possible pedestrians and cyclists should also be separated due to differences in speed, particularly with the rising popularity of e-bikes.

Special attention is needed for intersections, which can be particularly challenging and dangerous for cyclists if not planned sensitively.

4. Comfort

Cycling routes should be comfortable and attractive:
Planners should look to minimise nuisance for cyclists, including stops and delays. Prioritising cyclists at junctions helps to improve the cycling experience. Where possible, bridges, underpasses and other grade separation may be needed to avoid steep gradients and the physical exertion from climbing hills in the urban environment.

5. Attractiveness

Citizens are more likely to opt for the bicycle when the route is attractive:
Quiet, green, well-maintained streets have been found to be more attractive to cyclists, and encourage a feeling of safety. Links should pass through parks and green spaces, rather than industrial and deserted areas where possible.

Green Spaces (right)

Barcelona is looking to use green spaces and trees as part of its efforts to mitigate the effects of global warming. The city's 20-year tree masterplan aims to increase the proportion of land covered by trees from 25% to 30%, particularly along active travel networks [96].

The
Neighbourhood

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Transit-oriented development

In order to create communities where walking and cycling is feasible, the distance between facilities and amenities needs to support shorter distance trips. Designing neighbourhoods for walking and cycling starts with good planning.

Transit-Oriented Development (TOD) is a long standing, popular form of urban planning focused on minimising distances between residential, commercial, and recreational services (i.e. increasing densities). The central premise is to promote the use of public transport over private car use [93]. Different countries and cities use different spatial metrics, but most look to increase the density of services 400-800m around public transport stations. TOD encourages mixed use developments rather than zoning by land use.

Long-standing examples of TOD include Copenhagen's Finger Plan. The plan was formed in 1947, and was focused on post-war regeneration. Development has been concentrated along the suburban railway and metro lines that sprawl out from central Copenhagen and is an excellent example of how combining land use and transport planning can result in sustainable mobility patterns. Allocating housing alongside the public transport network has enabled a more sustainable form of suburban living in the Greater Copenhagen Area than is seen in many urban areas across the world [98].

A key aspect of the Five Finger Plan is that it is not just allocating housing, but also industrial, work, health and education centres. Each of the 'fingers' also includes important business centres where many prominent Danish and international firms are based. The result is two way commuting, as opposed to each finger making its way to the center every morning.
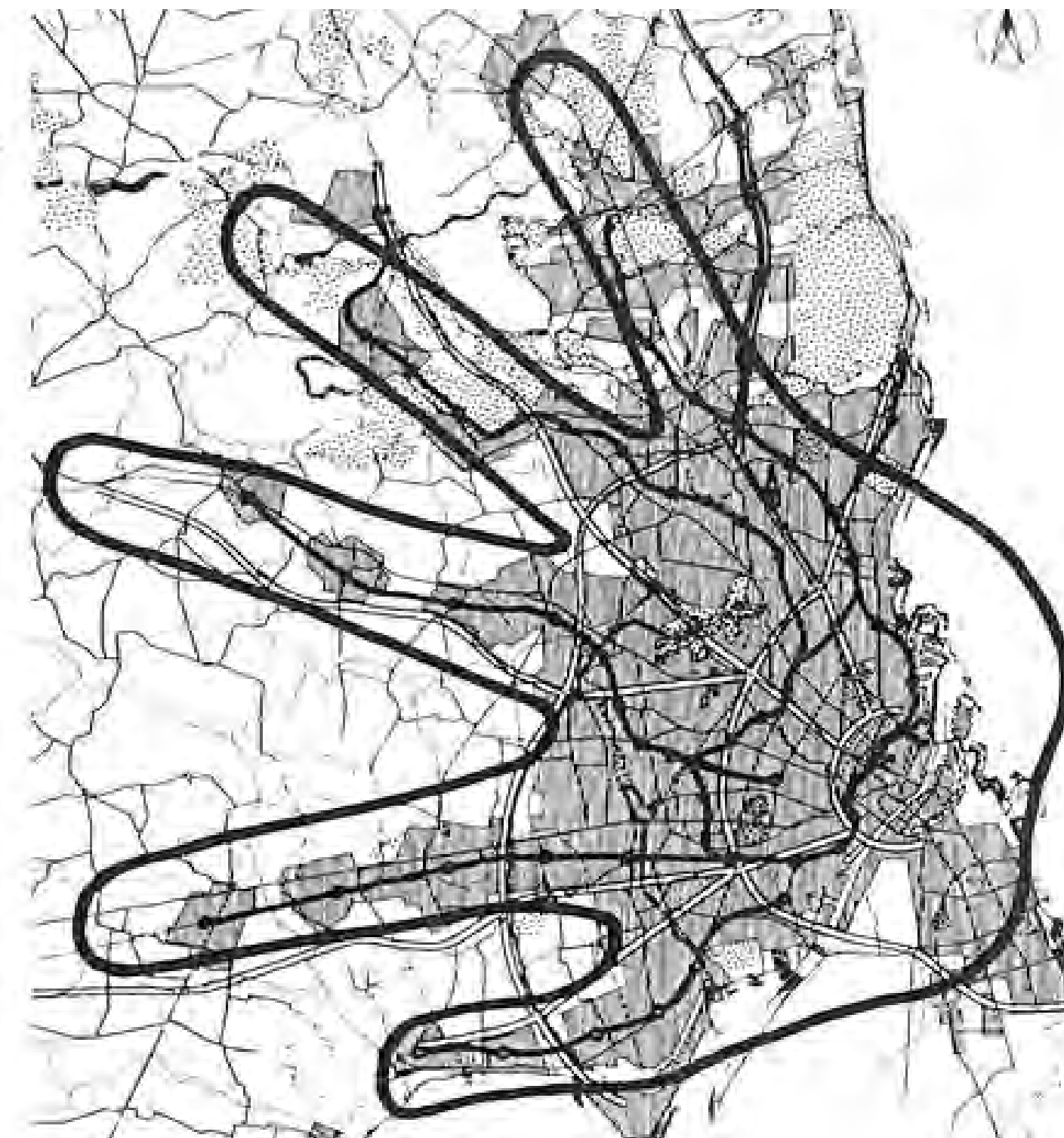
Copenhagen Finger Plan
© Danish Design Review

In 2020, New Zealand published their National Policy Statement on Urban Development (NPS-UD). This requires councils to enable 6-storey+ developments within 10 minute catchments of all rapid transit stations. The aim is to house the greatest possible number of residents within a short distance of the rapid transit network to reduce private car use [99].
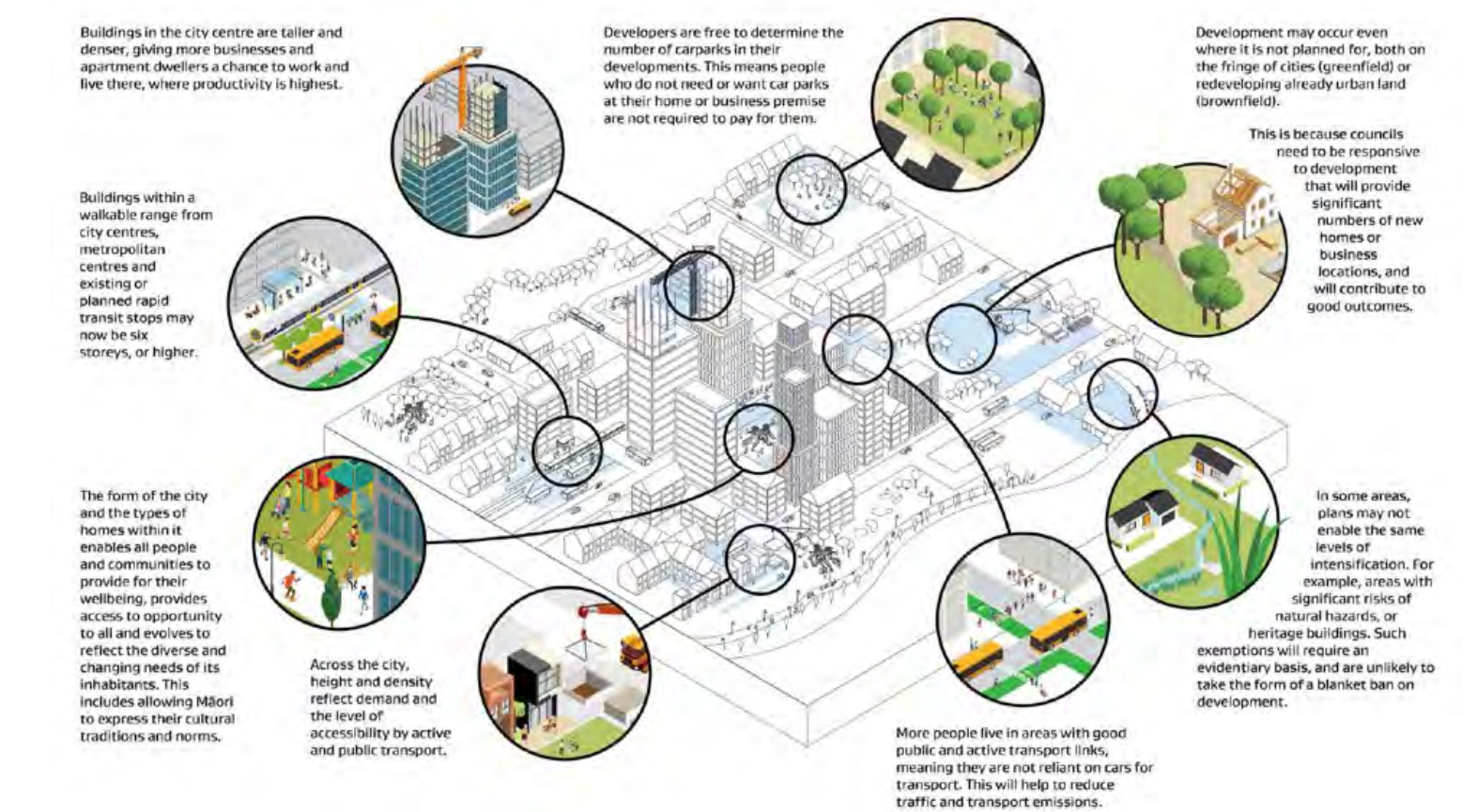
© New Zealand MfE and Ministry of Housing and Urban Development

The Neighbourhood

Creating active neighbourhoods

The rise in planning for sustainable neighbourhoods

Over the last few years, with rising concerns about the health and climate crises, planners have been returning to TOD, but with a greater focus on active modes alongside public transport. The transition to planning for active mobility has been accelerated since the start of the COVID-19 pandemic.

One of the most famous recent examples of planning for short, active trips is Barcelona's Superblocks, first introduced in 2016 [100].

The Superblocks are neighbourhoods of nine blocks where motorised traffic is restricted to the perimeter. The interiors are only accessible by motor vehicle for residents, essential services and deliveries. This frees up space for walking, cycling and plazas.

Whilst there was early push back from residents, they are now widely supported for their co-benefits for public space and air quality. The initial blocks are being expanded across the city, with an extensive bus network plan to reduce car ownership levels. To provide shade and improve air quality, the internal plazas will have more green space.

These have been an inspiration for many car-free city centres and pedestrianisation schemes around the world.

A Value-Action Gap in UK Planning?

The benefits of TOD have been known for decades, yet unsustainable development is still ongoing. Houses are built in suburbs and citizens are unable to overcome the distances to key services by walking or cycling. Public transport networks are not always attractive or extensive enough to fill the gaps, and car dependency continues.

The RTPI recently found that across the UK, new housing developments are forcing residents to rely on cars. Recent planning permissions for large developments in England would push public transport travel times to key employment centres to an hour. We need to make sure we are building homes where there are the facilities and services to support low-carbon transport [101].
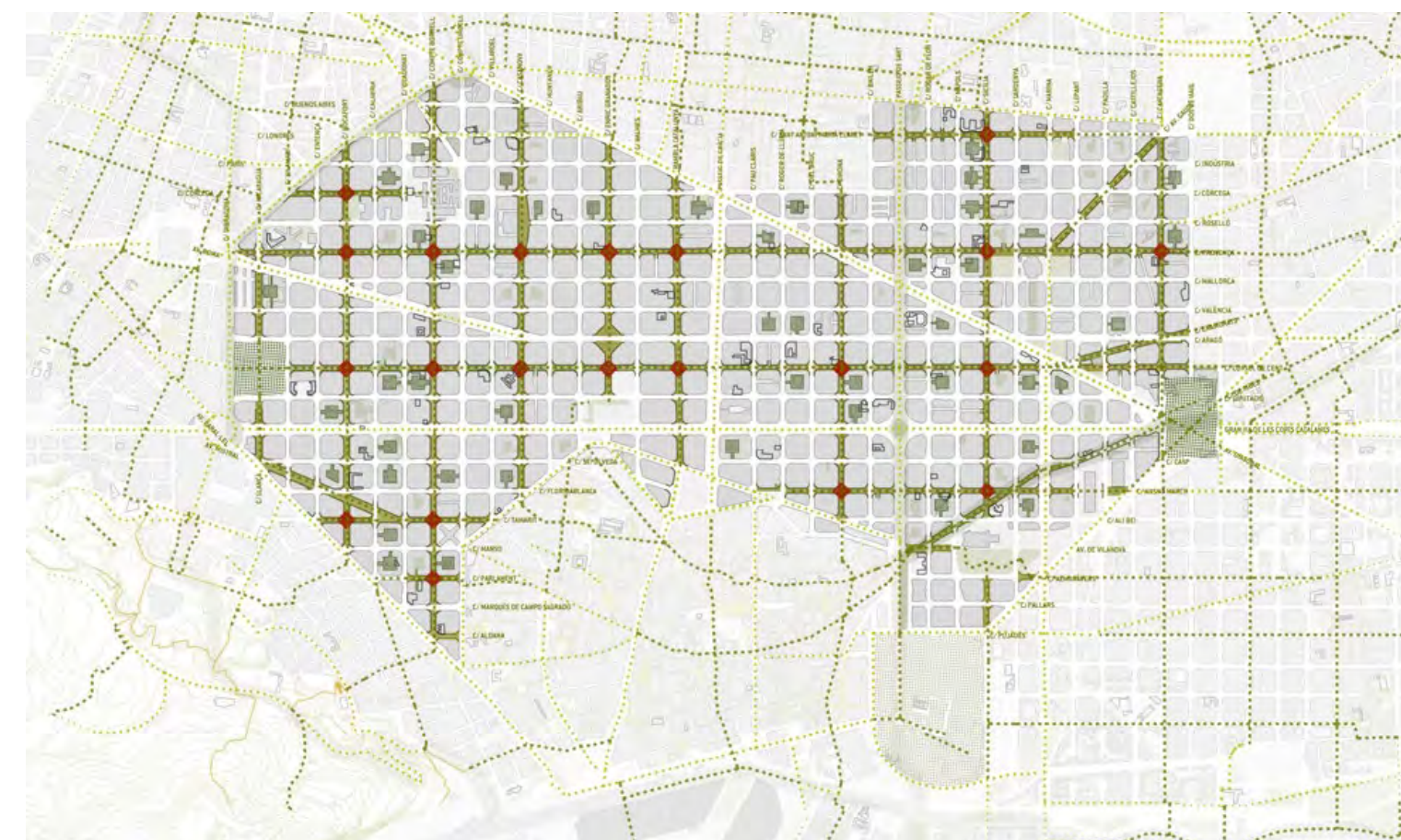
Plans to expand the Superblocks
© Ajuntament de Barcelona [102]

The Superblocks
© Nick Wehrli

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The proximate city

In 2020, Paris Mayor Anne Hidalgo put active planning at the front of her re-election campaign, popularising Carlos Moreno's concept of urban proximity into the blueprint for the '15 minute city (*ville du quart d'heure*)'. The 15 minute city refers to the idea that in cities, residents of each neighbourhood should be able to reach all necessary amenities (such as schools, offices, shops, parks, health centres) by a 15-minute walk or bike ride, moving away from car dependency [101].

Since announcing this plan, the 'coronapistes' (pop-up bike lanes) have spurred a large increase in cycling, and new policies have sustained this surge:

– Protecting the legacy of the coronapistes:
  making the protected lanes permanent

– Reallocating space away from car parking (removing 50% of spaces)

– Renovating the Champs-Élysées to create
  more space for walking and cycling.

Other countries and cities around the world have been inspired by the 15-minute city concept, and introduced their own plans for similar interventions:

– 10 minute towns in Ireland

– 20-Minute Neighbourhoods in Melbourne

– 20-Minute Neighbourhoods across Scotland

– 1 Minute City in Sweden

Ville du quart d'heure
© Micaël Dessin for Paris en Commun
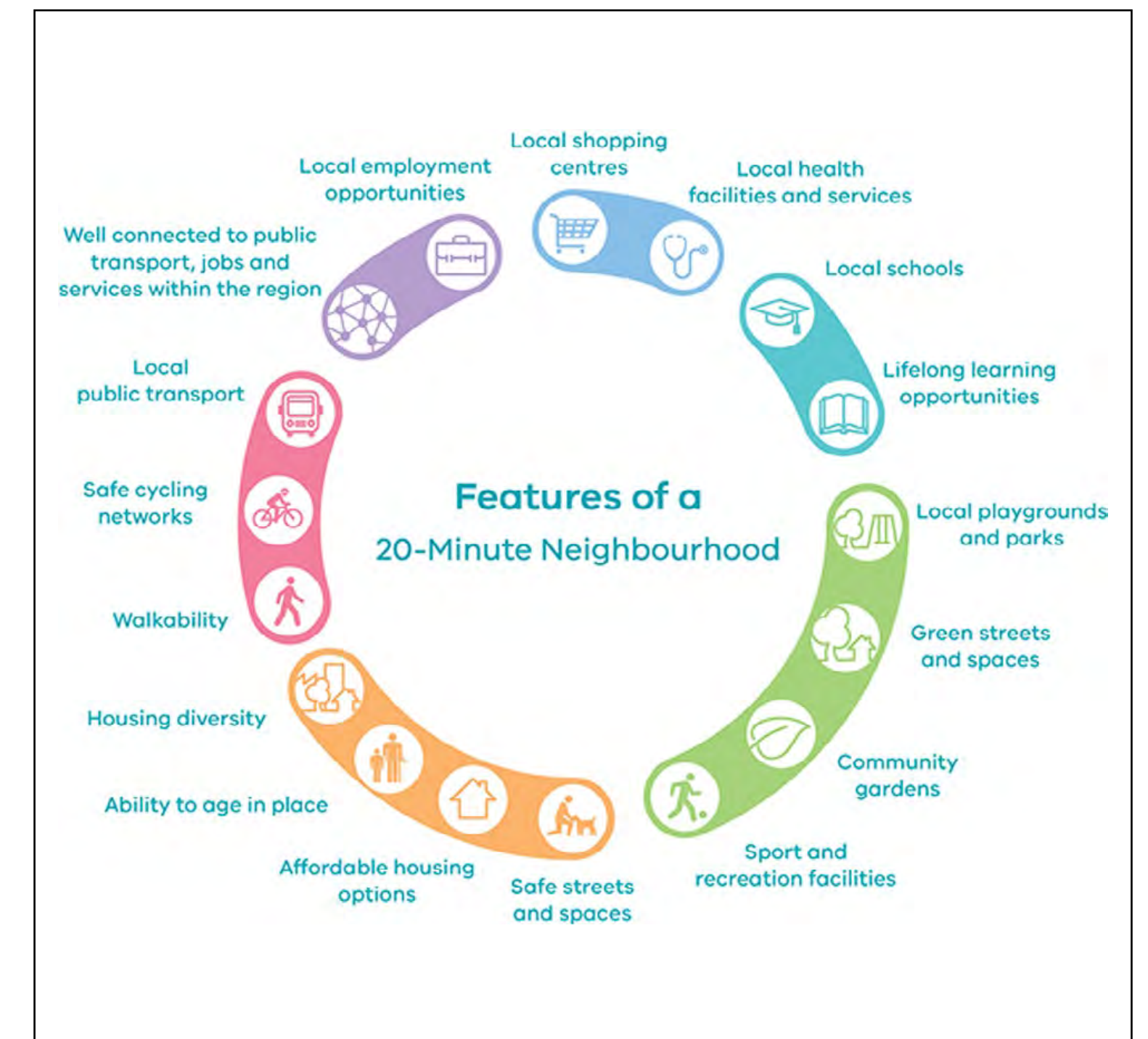
The 20 Minute Neighbourhood and its characteristics within Plan Melbourne 2017-2050
The plan acknowledges that many areas across the city require an upgrade to provide access to all neighbourhood features, whilst ensuring affordable housing options [104].

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Neighbourhood-focused planning

By locating services close together, citizens can also trip chain: combining separate activities into a single journey.

Regardless of the distance being targeted, all plans look to minimise the need for citizens to travel long distances, and therefore promote a mode shift to active and public modes - or a combination of the two.

Within the international planning community are a range of similar but different phrases related to this concept: 15-minute city, 20-minute neighbourhood, active city, and various combinations of one-way or return trip distances.

In the context of combining modes, and using e-bikes, the use of any particular time limit becomes less relevant. The 'Proximate City' emphasises the need to plan for active travel convenience, combining elements of TOD and walking and cycling design guidance (e.g. the principles of the CROW manual).

1 Minute City in Sweden

A concept to encourage placemaking and more citizen engagement with their immediate surroundings. The 'Street Moves' initiative encourages citizen workshops to discuss how local street space should be used, e.g. reducing parking in favour of parklets, street art and play areas. Four sites have been piloted in Stockholm, with other cities also joining the initiative [105, 106].

© Lundberg Design

Shared bikes and e-scooters in Paris, 2021
© Arup

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Active and equitable neighbourhoods

The rising popularity of 15-minute neighbourhoods has sparked debate regarding densification, gentrification and equity. By increasing the number of services around transit stations, are we just further improving areas that are already well serviced?

The premise of active train stations is that they should enable easy and safe access to key amenities, which allow for rail connections to other locations with different services. It is not feasible that every neighbourhood will have a large hospital, university, and leisure centre. Expecting small towns and suburban neighbourhoods to achieve '15 minute neighbourhood' status without considering public transport is not realistic, which is why developing active networks around inter-urban train stations is critical for ensuring large populations can complete sustainable door-to-door journeys and still reach a wide range of services. This is why parallel - rather than siloed - investments are needed in public and active transport networks.

The subtle difference between TOD and the 15-minute neighbourhood movement, is that TOD is focused on maximising land use and accessibility around a specified station, whereas 15-minute neighbourhoods are focused on improving movements within neighbourhoods, as well as the connections between them. This nuance is also critical for ensuring equitable outcomes.

The 15-minute neighbourhoods around inner city train stations are becoming more unaffordable for the average resident as a result of the access to jobs, goods and services that they possess. Improving these neighbourhoods can risk exacerbating socio-economic stratification by geography, whereas improving public and active transport networks around key employment areas - like Edinburgh, Malmö and Amsterdam - can reduce differences in accessibility [107]. Proactive governance is essential for ensuring that the benefits of the 15-minute city - improved accessibility, walkability, and environment - are not resulting in unsustainable transit-induced gentrification. Measures like affordability requirements and inclusionary zoning are encouraged within the literature in this field to avoid displacement of disadvantaged individuals and families from areas well served by public transport [108]. Participatory planning processes can also help to incorporate all citizen voices and avoid unintended negative effects [109].

Active Neighbourhood
Ensuring equal access to libraries, community centres & employment opportunities is a key premise of an equitable active neighbourhood.
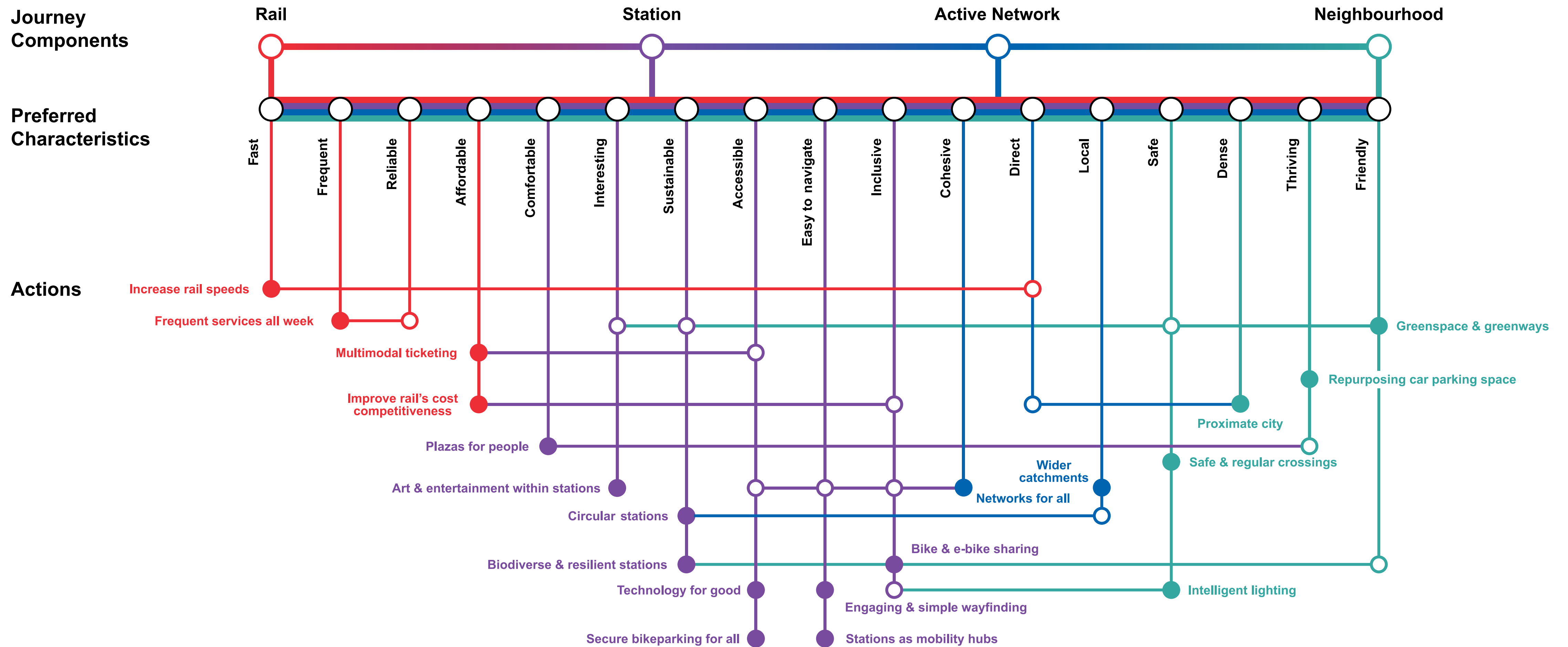© Arup

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20 Actions for Active Train Stations

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Insights from case study stations and networks

The inter-urban corridors in the Netherlands, Sweden and the UK were examined, with a particular focus on the eight metrics shown in the graphic.

The analysis indicates that all six locations have improvements that can be made to enhance active-train trips. The Dutch and Swedish stations, networks and rail services were found to be more well-suited to promoting walking and cycling to and from stations than the UK locations.
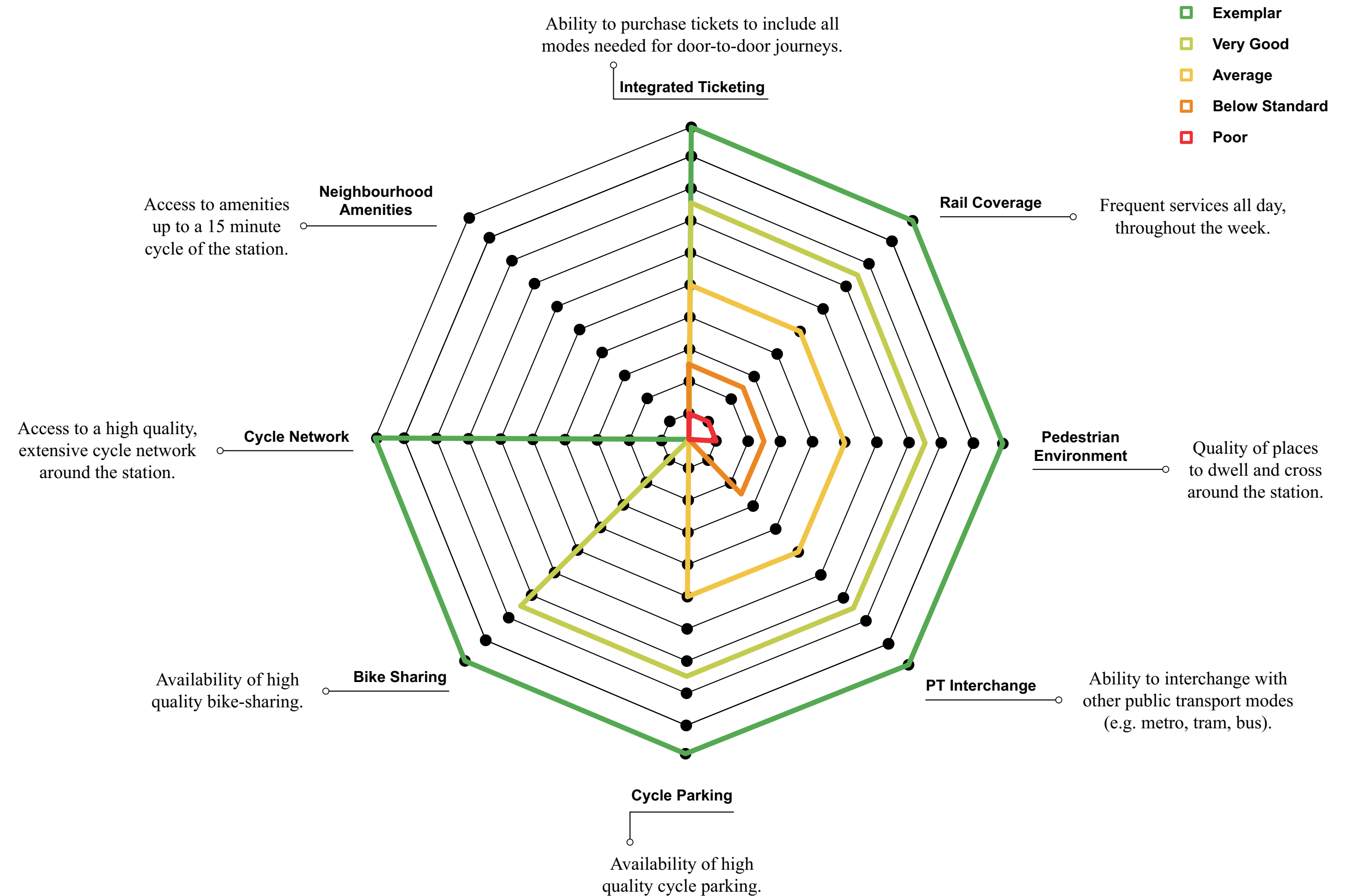
Each case study has its own constraints:

– In Amsterdam, the space taken up by water within a 15 minute radius reduces the land for greenspace, and amenities accessible to the north of the station.

– In Lund the cobbled streets are successful in promoting lower vehicle speeds but are less comfortable for all types of cycling.

– In Malmö, the absence of a metro or tram system limits the possibility for public transport interchange.

– In Edinburgh, the proximity of the train station to the main shopping street reduces the possibility for large, open plazas at station entries and exits.
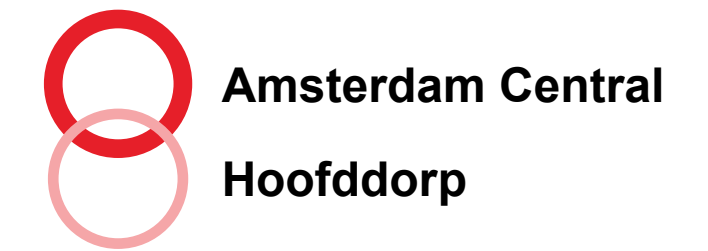
The main differences between the UK and European networks are:

– A lack of integrated ticketing due to privatised rail;

– An absence of bike-sharing facilities;

– An absence of plazas outside the stations;

– A significant reduction in rail services on weekends, particularly Sundays (compared with weekdays);

– Patchy cycle networks that do not connect to and from the train stations;

– A lack of extensive and attractive cycle parking; and

– Large car parking facilities, which in the case of Linlithgow are free of charge.

Ability to purchase tickets to include all modes needed for door-to-door journeys.

Integrated Ticketing

Access to amenities up to a 15 minute cycle of the station.

Neighbourhood Amenities

Access to a high quality, extensive cycle network around the station.

Cycle Network

Availability of high quality bike-sharing.

Bike Sharing

Rail Coverage

Frequent services all day, throughout the week.

Pedestrian Environment

Quality of places to dwell and cross around the station.

PT Interchange

Ability to interchange with other public transport modes (e.g. metro, tram, bus).

Cycle Parking

Availability of high quality cycle parking.

- ☐ Exemplar
- ☐ Very Good
- ☐ Average
- ☐ Below Standard
- ☐ Poor

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Case study insights: The Netherlands

Amsterdam Central

Hoofddorp

Integrated ticketing
Rail passengers are able to use the NS-app
to purchase tickets to include rail, metro, bus, tram
and search for shared bikes (OV-fiets).

Neighbourhood amenities
Within a 15 minute cycle of the stations are all
categories of amenities: health, education, leisure,
fitness, greenspace, food and bike sharing stations.

Cycle network
Both stations are accessible by dedicated cycle paths
and are connected to extensive networks.

Bike sharing
Bike-sharing available at both stations.

Rail coverage
4 trains per hour most of the week, with some gaps in
off-peak times.

Pedestrian environment
Pedestrian areas outside of both statsion could be
improved with more benches and planting.

Public transport interchange
Good options for PT interchange at both stations,
particularly at Amsterdam with the metro, bus
and tram.

Cycle parking
Exemplar cycle parking at both stations.

Integrated ticketing

Neighbourhood amenities

Rail coverage

Cycle network

Pedestrian environment

Bike sharing

Public transport Interchange

Cycle parking
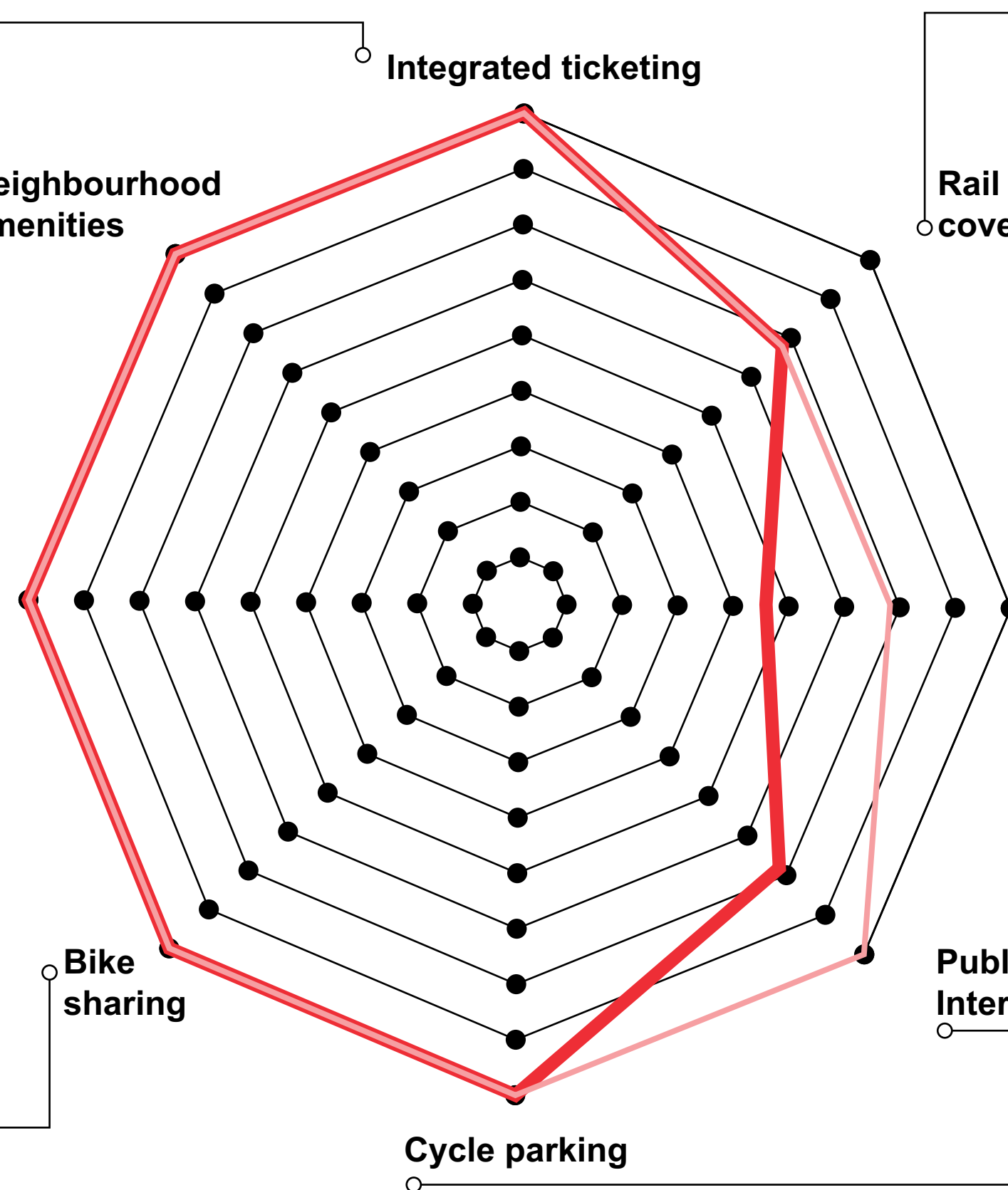
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Case study insights: Sweden

⬤ **Malmö Central**
◯ **Lund Central**

Integrated ticketing
Rail passengers are able to use the Skånetrafiken app to purchase tickets to include rail, bus, and tram. The app also covers Öresundståg trains to Denmark via Copenhagen. Shared bikes are not currently integrated.

Neighbourhood amenities
Within a 15 minute cycle of the stations are all categories of amenities: health, education, leisure, fitness, greenspace, food and bike-sharing stations.

Cycle network
Malmö C is connected to a dedicated cycle network. Around Lund C, cyclists mix with buses and taxis in a 30 kph area before reaching the dedicated network.

Bike sharing
Bike-sharing available at both stations.
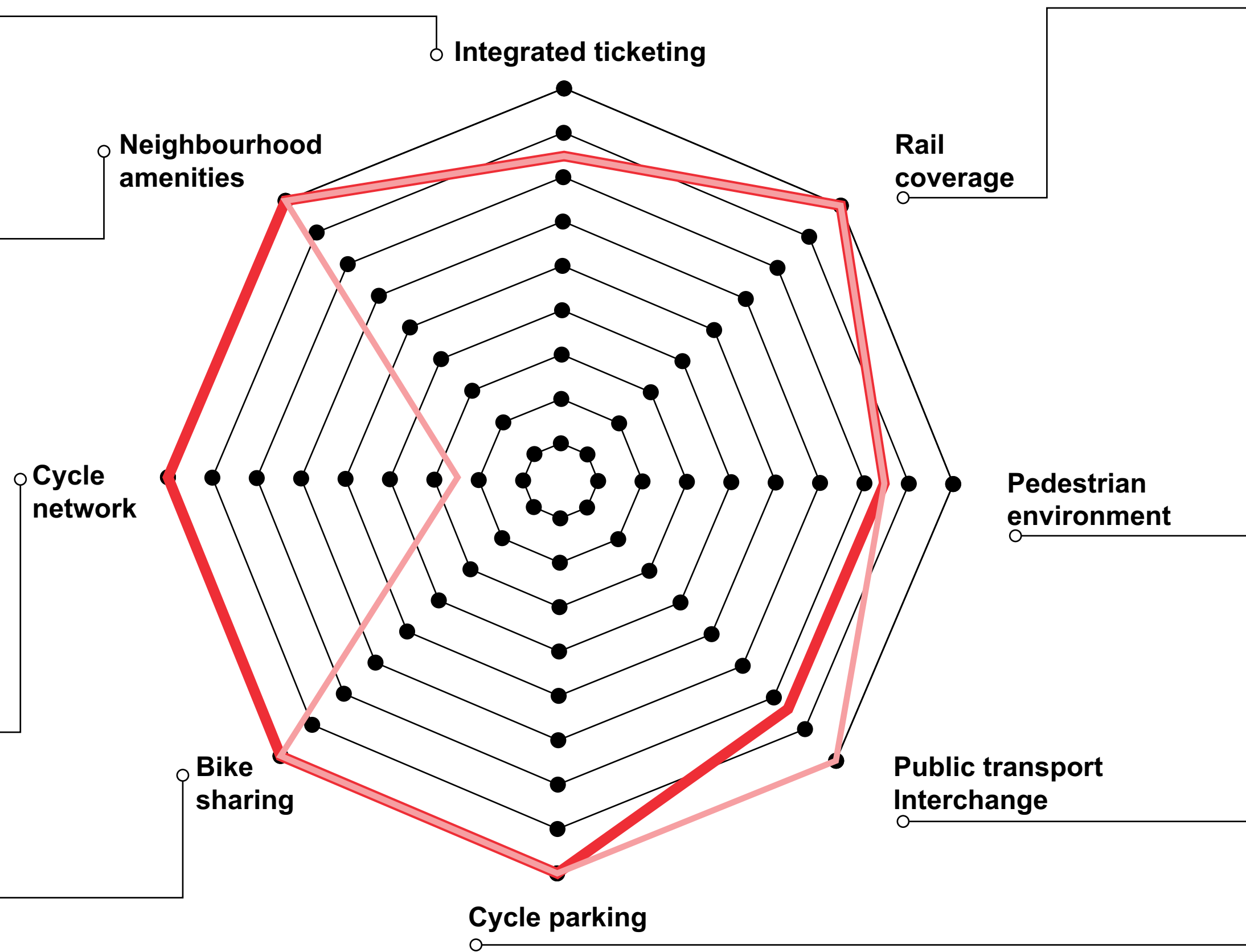
Rail coverage
Exemplar rail coverage throughout the day, all week.

Pedestrian environment
High quality crossing facilities outside each station. Benches and planting are also found outside the station entries/exits.

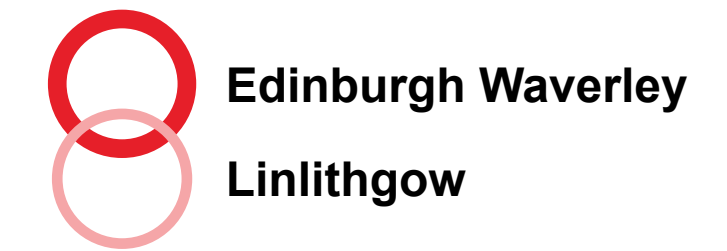**Public transport interchange**
Good options for PT interchange at both stations, particularly at Lund C with bus and tram connections. Local, regional and international buses depart from Malmö C.

Cycle parking
Exemplar cycle parking at both stations.

Radar chart axes: Integrated ticketing, Rail coverage, Pedestrian environment, Public transport Interchange, Cycle parking, Bike sharing, Cycle network, Neighbourhood amenities

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Case study insights: UK

Edinburgh Waverley
Linlithgow

Integrated ticketing
Rail passengers are not able to purchase tickets for other transport modes on the same app as their train ticket.

Neighbourhood amenities
Within a 15 minute cycle of Edinburgh Waverley are all categories of amenities: health, education, leisure, fitness, greenspace, food and bike-sharing stations. There are no fitness or educational facilities within this radius for Linlithgow.

Cycle network
There is no dedicated cycle network accessible from Edinburgh Waverley. The Linlithgow canal shared-use path connects to the station, although this is not connected with the High Street or beyond.

Bike sharing
Bike-sharing is not available at either station. Just Eat shared bicycles were removed from Edinburgh in 2021.
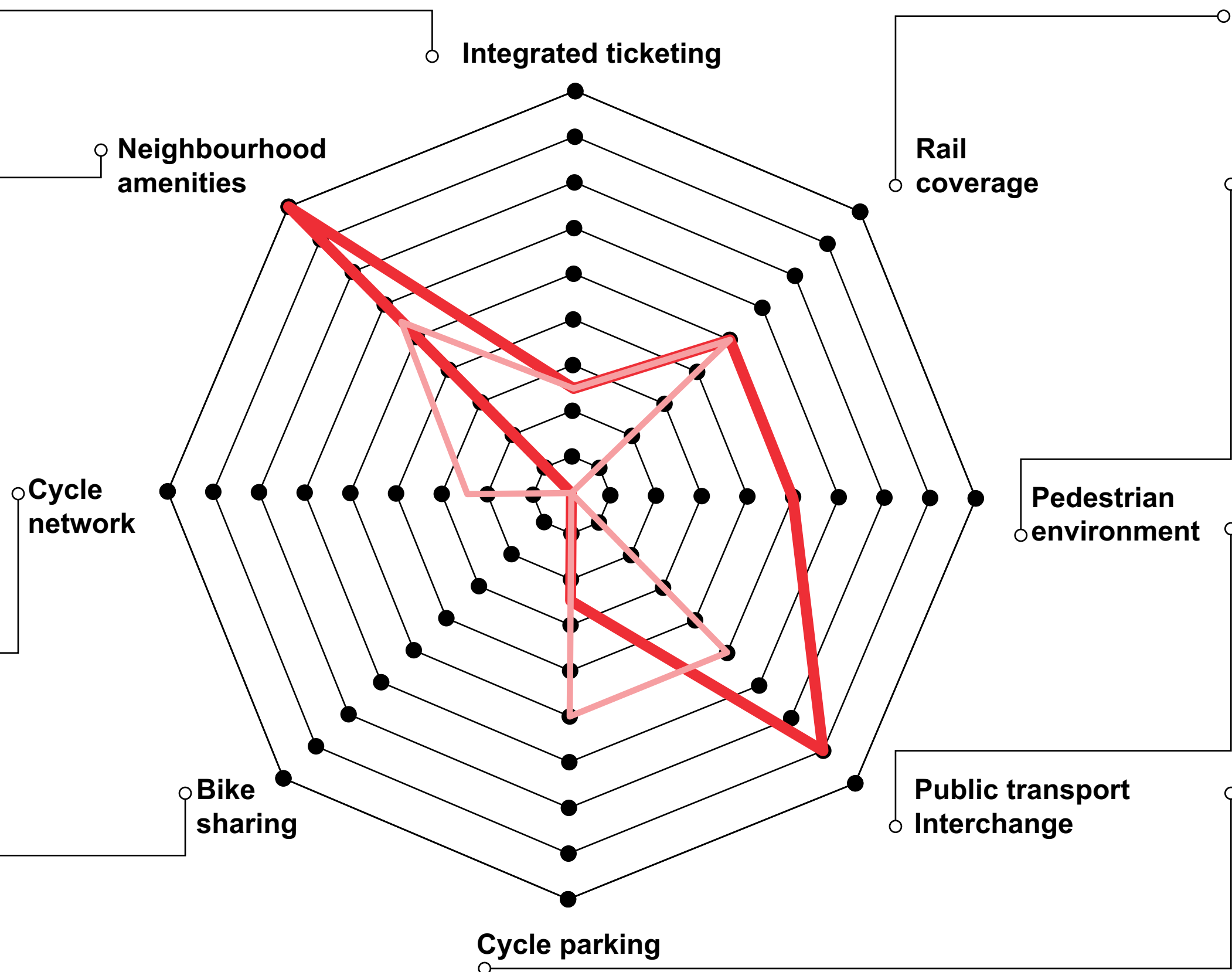
Rail coverage
Rail frequency is weighted towards peak periods, with gaps in off-peak times, with particularly low coverage on weekends.

Pedestrian environment
Some signalised crossings outside Waverley, and a newly traffic-free access via Waverley Bridge. Edinburgh station access is via the often crowded Princes Street (with a large number of taxis). The station is below-ground, and the aboveground section has been converted into a crowded pop-up bar and dining area. There are no pedestrian facilities or nearby safe crossings at Linlithgow.

Public transport interchange
Good options for PT interchange at Edinburgh (bus and tram), however the bus drop off zone is mixed with taxis and pedestrians on the city's main shopping street, making it a crowded place for interchange. Bus connections are possible at Linlithgow at a bay on the High Street.

Cycle parking
Bikeparking spaces are limited, particularly at Waverley given the scale of the station. Waverley spaces are below ground level and although there are wheel ramps there are many stairs to navigate to reach facilities. Free carparking at Linlithgow does not promote cycle trips to the station.

Radar chart axes: Integrated ticketing, Rail coverage, Pedestrian environment, Public transport Interchange, Cycle parking, Bike sharing, Cycle network, Neighbourhood amenities

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Where to start?

Identifying priorities for improving active networks

The funding available for local authorities to improve the active travel network is finite. Understanding the characteristics of the network and surrounding environment that result in increased use could therefore help local authorities prioritise improvements and where funding is spent. Using regression analysis, we can understand the features of the active travel network and surrounding environment that correlate with higher cycle use.

Cycle counts were available for 58 locations in Edinburgh which overlapped with the cycle network. The median daily count at each location was calculated separately for February and September using data from 2019-2021. The cycle count data did not differ significantly following the COVID-19 pandemic.

The characteristics considered in the analysis included:

– The lighting, path, surface and tree cover qualities of the nearby
  cycle network links, as determined earlier in the study

– The gradient, speed limit and highway type
  of the nearby cycle network links

– The surrounding land use as determined
  by the Copernicus urban atlas dataset

– The number of different types of amenities
  and cycle crossings in the surrounding area

February cycle counts

- ≤50
- ≤100
- ≤150
- ≤200
- ≤300
- ≤400
- ≤500
- ≤1000
- ≤2000
- ≥2000

The map above shows the cycle count locations in Edinburgh available for analysis of cycle use in February.

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Where to start?

Regression analysis

The regression analysis conducted for Edinburgh is intended as a proof of concept for a regression approach to understand the environmental factors that correlate with higher cycle use in this location.

An analysis dataset was produced by combining the datasets and assigning the characteristics of the surrounding environment to each cycle count location. For each cycle count:
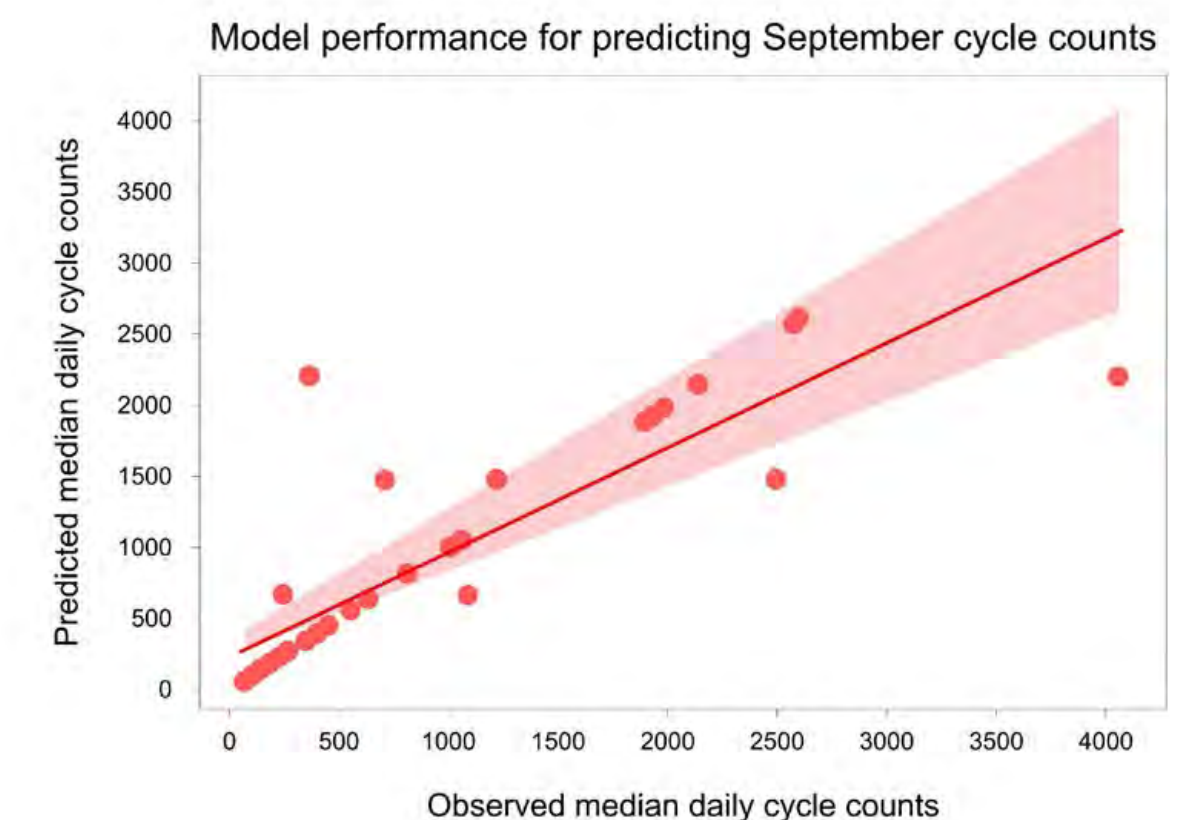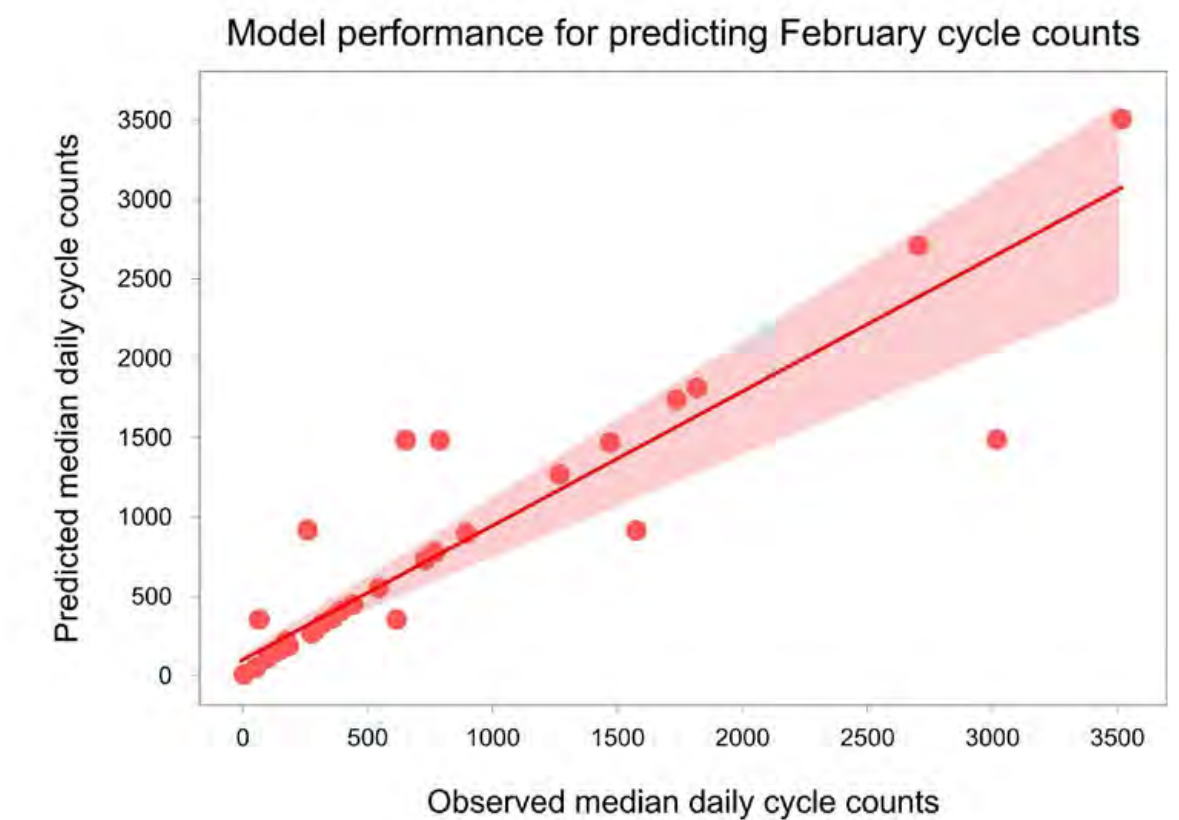
1. The number of each type of amenity and the number of cyclist crossings within 100 metres of each cycle count was calculated.

2. The nearest five urban atlas land use type polygons were identified to understand the type of land surrounding the cycle count.

3. The nearest cycle links to each cycle count were identified using a k-nearest neighbour analysis and an average of their characteristics were calculated.

A number of regression models were tested, however, due to the non-linear nature of the cycle count data, an extreme gradient boosting regression model was able to explain most variance in the cycle counts. These models were able to explain 84% of the variance in median daily cycle counts in February and 89% of variance in median daily cycle counts in September.

The features of the surrounding environment that contributed most to the predictive capacity of each model were then identified. These can be thought of as the most important factors for predicting the use of the cycle network. These are presented and discussed in the following pages.

It is important to note that the results of this analysis show the features of the environment which have high correlation with cycle use. This does not, however, imply causation. Whilst the features identified are linked to high cycle use, they may not necessarily cause high cycle use.

Model performance for predicting February cycle counts

Model performance for predicting September cycle counts

The graphs to the right compare the observed cycle count for each count location with the model prediction for cycle count at that location.

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Where to start?

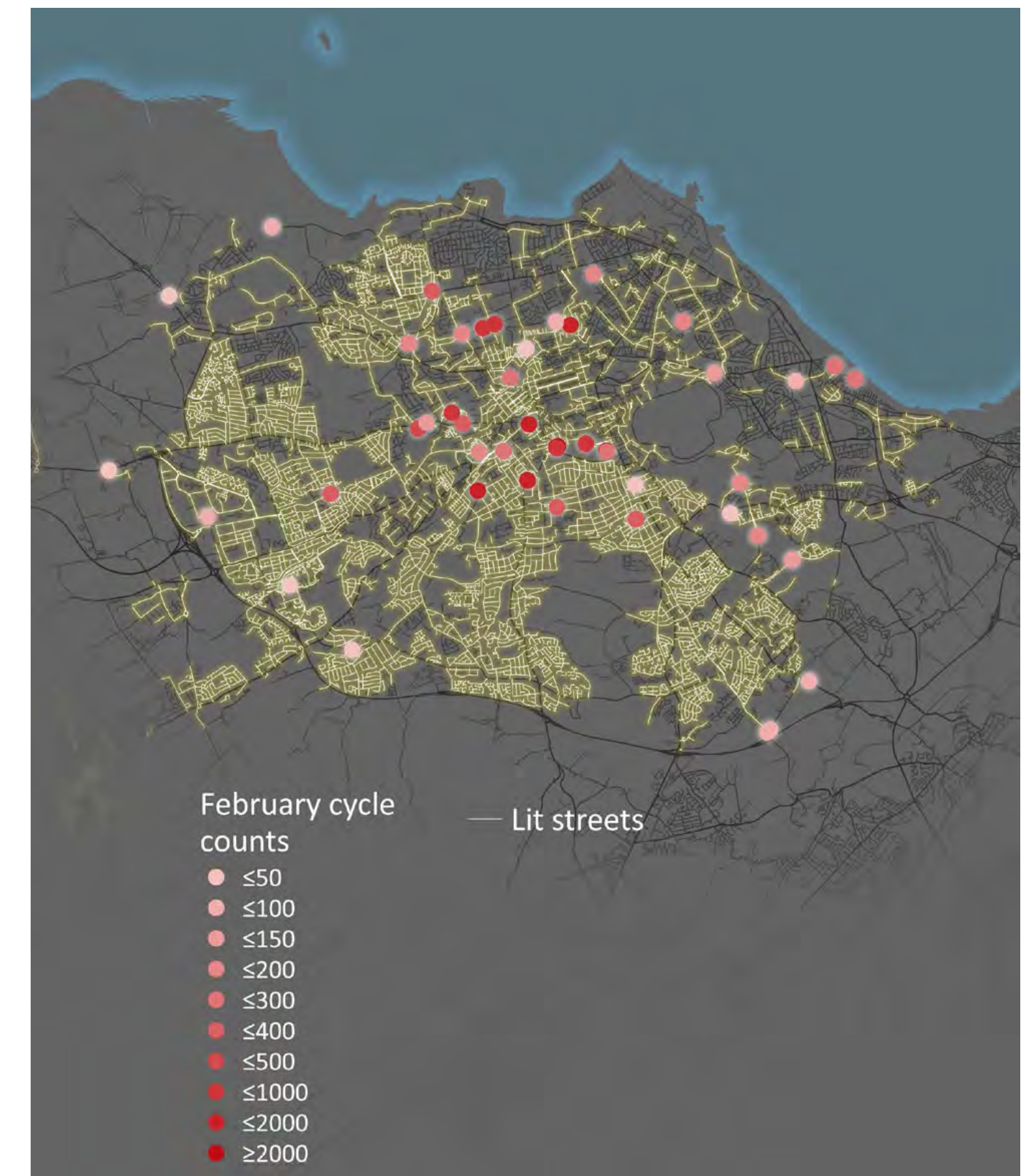**Factors affecting propensity to cycle in February**

In February, the two most important factors behind the propensity to cycle across the city were the presence of crossing facilities and whether the route was lit.

Lighting is an important part of cycling safety. Having well lit paths aids navigation, reduces the need for extremely bright personal lights on bikes, and increases the feeling of safety. Lighting is particularly important in February, where there are fewer daylight hours compared with summer months. Lighting is also correlated with areas of retail and commercial activity, where cycle trips are likely to start, end or pass through.

Higher cycling was observed in areas with more Crossing facilities, including signalised junctions. Areas with numerous crossings encourage cycling as they enable users to cross safely, and access/egress from dedicated cycle networks to residential streets. Crossings are also more typically found in areas with high retail density (e.g. high streets), which are common trip generators and attractors.

A higher prevalence of bike parking locations and discontinuous dense urban areas were also correlated with greater cycling. The very dense urban areas within the city (e.g. central Edinburgh around Princes Street and Waverley Station) do not have dedicated cycling infrastructure and high bus and tram flows reduce the comfort of any on-road cycling. In comparison, the more discontinuous dense urban areas have lower bus flows and trams are not present - making on-road cycling more amenable - and parts have dedicated cycling infrastructure.

Higher cycling was also observed in areas with a higher density of health, education and leisure facilities (popular trip generators and attractors), but areas with steeper gradients were associated with lower levels of cycling, likely due to the additional physical demands of cycling uphill.

February cycle counts

●	≤50
●	≤100
●	≤150
●	≤200
●	≤300
●	≤400
●	≤500
●	≤1000
●	≤2000
●	≥2000

— Lit streets

Lighting on nearby cycle network links was also linked to higher cycle use.

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Where to start?

Factors affecting propensity to cycle in September

Similar to February, crossing facilities were strongly linked to higher cycling counts. The presence of street lighting was also identified as a good predictor of cycle use, however the relationship is weaker than for February, likely due to the increase hours of daylight in September.
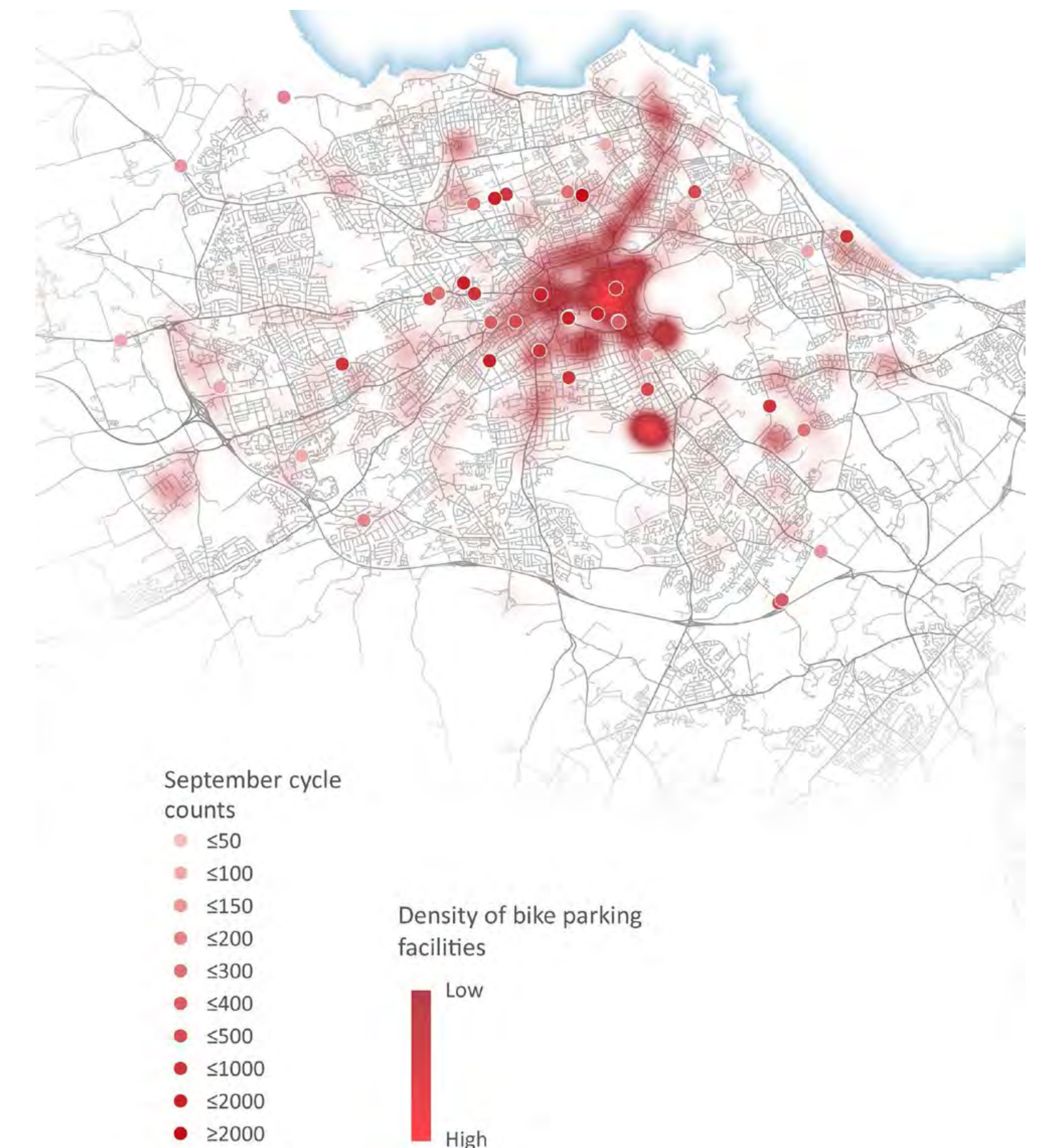
In September, the link between cycle use and gradient increases, with lower cycle use on links with steeper gradients, whilst cycle use is also higher in areas with a greater density of education facilities. This could be associated with the start of a new academic term, when people return to school or university from a summer break and the weather is still good, people are more likely to favour cycling as a mode of transport to get to lessons or lectures.

A particularly strong link was also found between cycle use in September and the presence of bike parking locations. Residents are more likely to cycle to a location if they know that dedicated cycle parking infrastructure exists in the area. That way, the cyclist doesn't have to spend time identifying a location to leave their bike and can continue with their activities in a more streamlined, stress free manner. In locations where car parking is more readily available than bike parking, residents are more likely to drive instead.

Cycling levels were also higher in areas with lower speed limits (20 mph) and locations where the cycle paths are segregated from cars. These environments provide a more comfortable cycling environment. Some areas with 20mph limits also have further traffic calming measures and are therefore less popular through routes for cars, whilst cyclists are likely to seek dedicated, segregated cycling routes wherever possible.
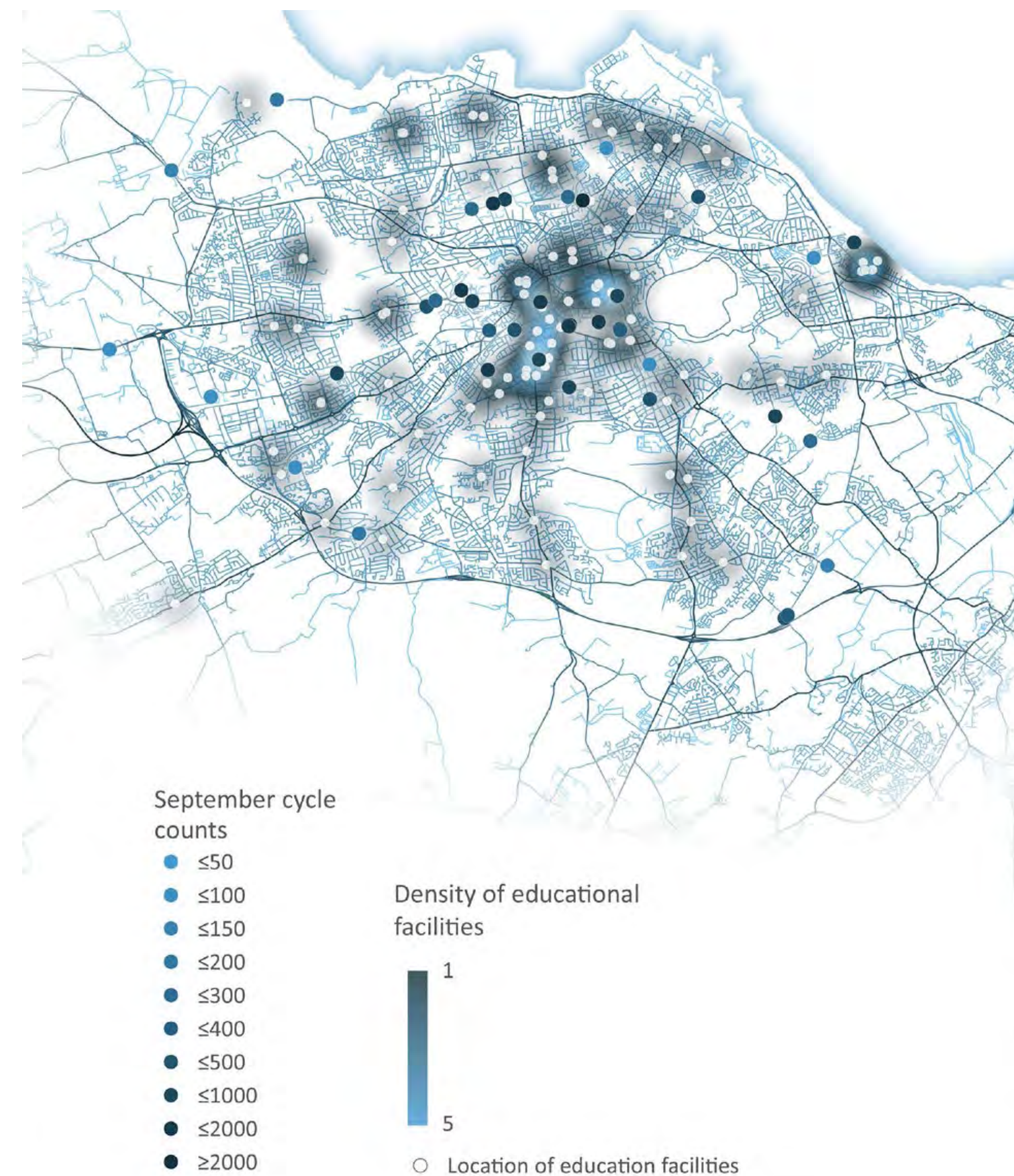
A higher density of education facilities in the surrounding area was an important factor in predicted cycle use in September.

Higher cycle use is correlated with areas where there is a higher density of places to park bikes.

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Lessons from the regression analysis

This analysis into the factors affecting cycle use in Edinburgh indicates that higher cycle use is observed in locations with the following characteristics:

– Greater availability of cyclist crossing locations

– Greater availability of dedicated bike parking locations

– The presence of street lighting

– Nearby cycle links with lower gradients

– Higher density of amenities, particularly health, education, leisure and food amenities

– Lower traffic speeds, or dedicated cycle routes that are segregated from traffic.

The analysis also shows that the relative importance of some characteristics change at different times of the year. For example, street lighting is a more important factor in the winter when there are less hours of daylight. However, the factors that are most strongly correlated with cycle use remain the same at different times of the year.

These findings can start to inform local authorities on the characteristics they could look to prioritise when planning improvements to their local cycling infrastructure in order to maximise cycle use. However, it's important to note that more detailed analysis is required to confirm that these relationships are causational. For example, it is possible that cycle crossings and bike parking facilities were introduced to service areas where cycle use was already high, rather than these factors resulting in higher cycle use themselves. The findings of this analysis provide a useful starting point for that further investigation.

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Making it Happen: 20 Actions for Active Train Stations

The Rail Service

Frequent services all week:
To enable mode shift, train services need to be readily available on weekends, not just weekdays

1

Increase rail speeds:
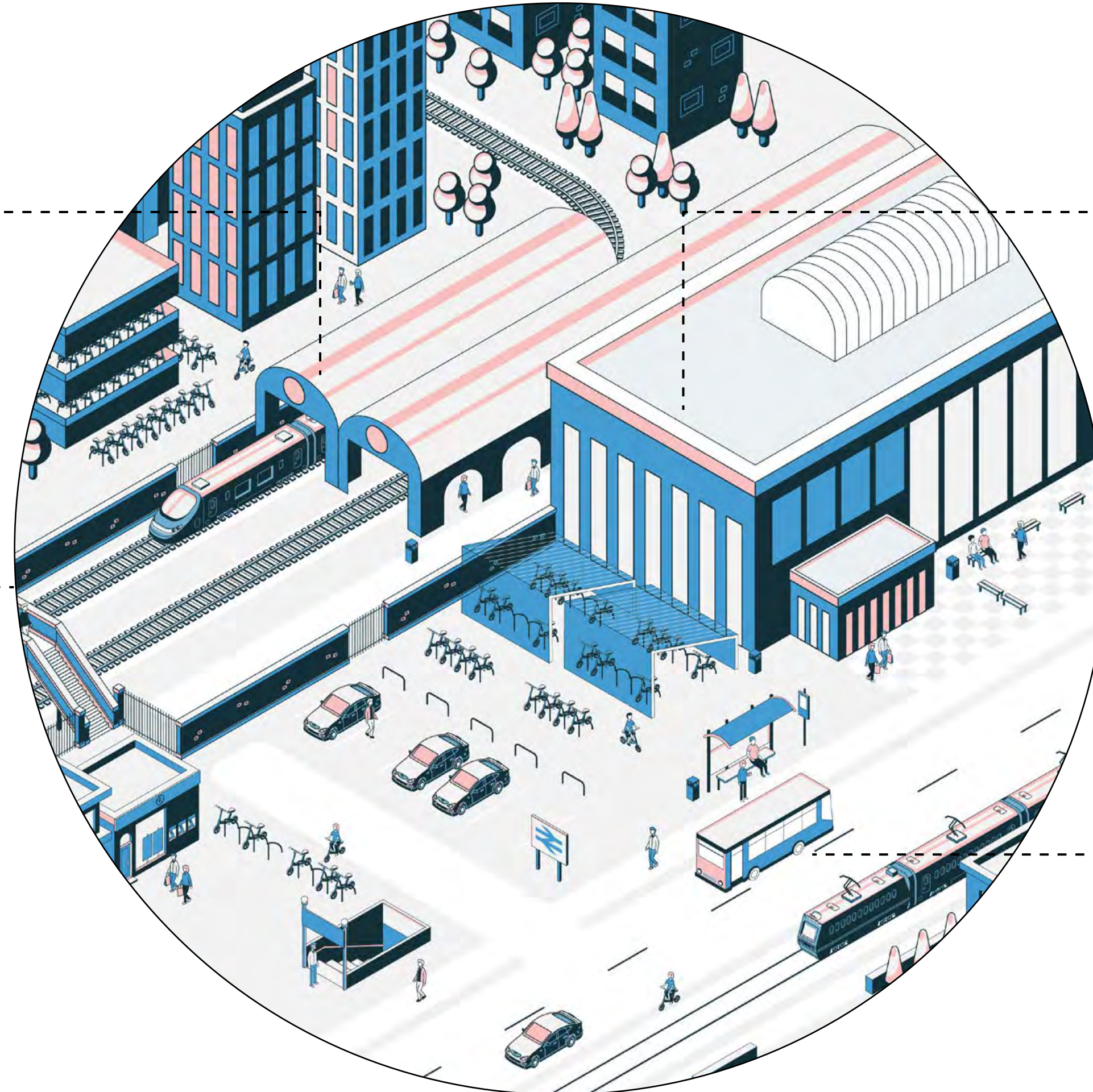Where possible, reduce journey times for customers

2

Improve rail's cost competitiveness:
Communicate the costs of driving to better reflect true costs

3

Multi-modal ticketing:
Tickets to include train and feeder modes such as bike-sharing, e-scooters and bus

4

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The Station

Art & entertainment within stations:
Integrate art, culture and retail into stations to improve the user experience without compromising on ease of navigation

5

Circular stations:
Reducing the embodied carbon in station construction and renovation (modular design, energy positive). Use the stations and surrounding land to generate renewable energy to support e-bike and e-scooter charging (e.g. solar panels)

6

Stations as mobility hubs:
Integrating bus, tram, metro, bike-sharing and e-scooter offerings into stations

7

8
Technology for good:
Utilising apps and technology to enhance accessibility and the customer experience

9
Plazas for people:
Car and clutter-free station entrances to increase sociability and ease of intermodality

10
Bike & e-bike sharing:
Providing shared bikes to reduce the need for ownership and more flexible use. E-bikes and the relevant charging infrastructure expand the reach in terms of customers and geography

11
Biodiverse & resilient stations:
Introduce locally sensitive planting around stations

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The Network
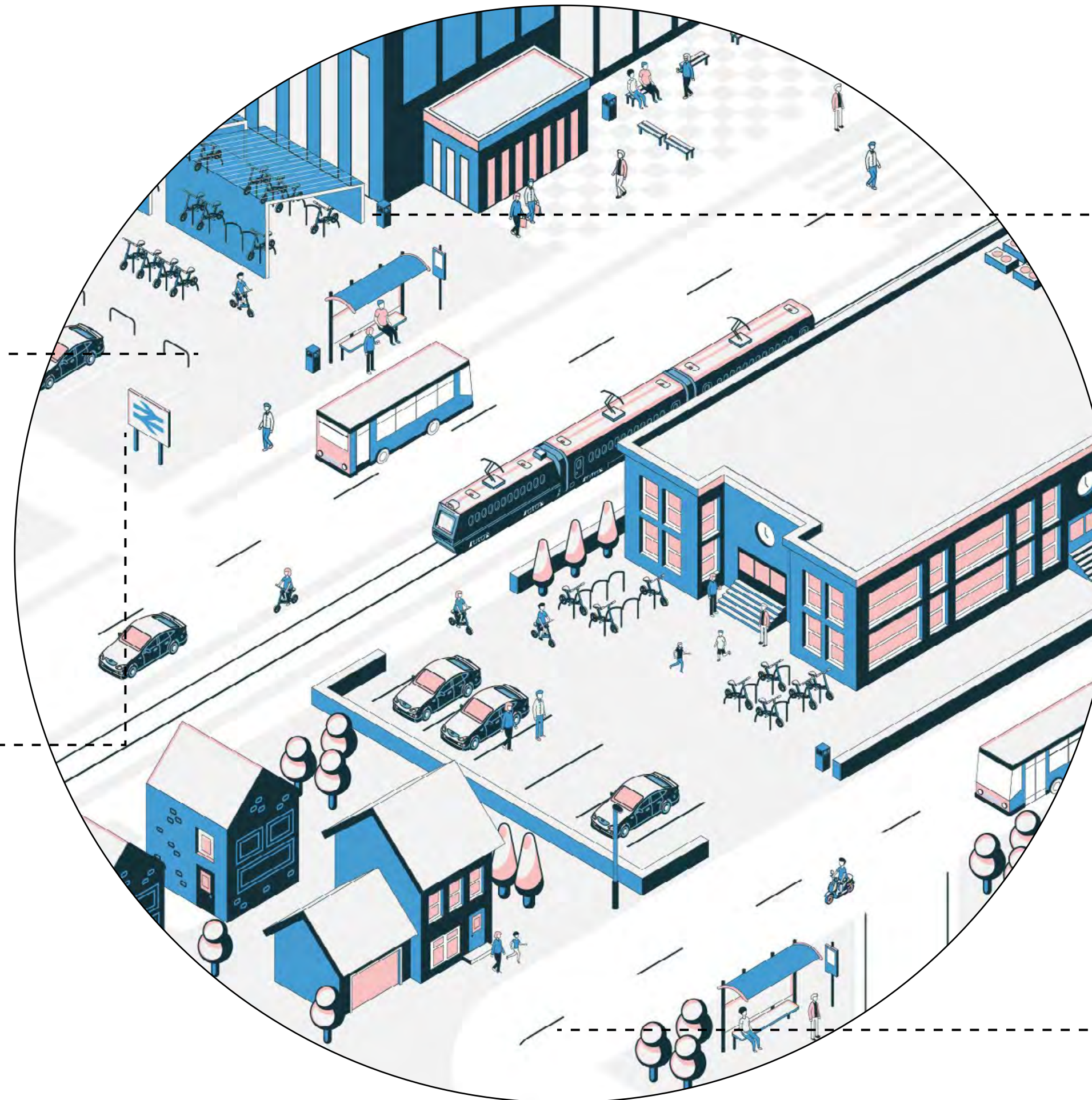
Safe and regular crossings:
Reduce delays and increase safety for pedestrians and cyclists accessing stations

12

14
Networks for all:
Designs to support all types of pedestrians and cyclists in terms of the network, bike-parking and relevant facilities (cargo bikes, adapted bikes, mobility scooters etc.)

Engaging & simple wayfinding:
To aid navigation to, from and around the stations

13

15
Wider catchments:
Expand the typically small planning catchments to consider possible users up to 5km from the station

Making it Happen: 20 Actions for Active Train Stations

The Neighbourhood

Repurposing car parking space:
Converting large station car parks for placemaking and community use

16

17 **Intelligent lighting:**
Using lighting to increase safety, accessibility and visual amenity

18 **Proximate City:**
Design neighbourhoods for active-train trips, combining aspects of the 15-minute city and TOD paradigms

19 **Greenspace & greenways:**
Tree-lined streets and public parks around the station to increase attractiveness and improve air quality

20 **Secure bike parking:**
Making the bike parking attractive, easy to use and well-located

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References

1. IPCC (2018). Special report on 1.5 degrees, Chapter 2
2. DfT (2021). Decarbonising Transport
3. UNFCCC. The Paris Agreement
4. IPPR (2020). All Aboard
5. Knobloch et al (2020). Net emission reductions from electric cars and heat pumps in 59 world regions over time
6. European Commission. European Year of Rail
7. DfT (2021). Great British Railways: Williams-Shapps Plan for Rail
8. European Commission. Rail is key to decarbonise the transport sector and contribute to the EU's green recovery
9. Bloomberg (2021). France short-haul flight ban points way toward cleaner aviation
10. Midnight Trains (2021). Midnight Trains
11. Tardivo et al (2021). COVID-19 Impact on Transport: A Paper from the Railways' Systems Research Perspective COVID impacts on rail
12. ORR (2020). Regulator's rail finance report highlights impact of pandemic
13. DfT National Statistics (2021). Road traffic estimates in Great Britain 2020
14. ONS (2021). COVID indicators
15. DfT (2014). National Travel Survey 2014: Multi-stage trips
16. ECF. Marrying Cycling and Public Transport
17. MIT Senseable City Lab. Unparking
18. Glazener and Khreis (2019). Transforming Our Cities: Best Practices Towards Clean Air and Active Transportation
19. TfL. Walking and Cycling: The economic benefits
20. Raje and Saffrey (2016). The Value of Cycling
21. UIC (2010). High speed rail - Fast track to sustainable mobility
22. WWF (2021). Living Planet Report 2021
23. DfT (2009). Productive Use of Rail Travel Time and the Valuation of Travel Time Savings for Rail Business Travellers
24. ERS (2016). Health at Work: Economic Evidence Report 2016
25. RSSB (2021). Rail still safer and greener than road
26. EU Agency for Railways (2021). Study: rail travel remains safer than car travel, even during the pandemic
27. ORR (2021). Rail Safety
28. EC (2020). Road Traffic Fatalities in the EU in 2019
29. Project for Public Spaces (2008). Donald Appleyard
30. Fast Company (2020). Paris' mayor has a dream of 'the 15-minute city'
31. Big Plan Big Changes. Investment Report 2020
32. Statista (2021). Share of regional and local passenger rail services classified as punctual in Europe in 2018, by country
33. UK Parliament House of Commons Library (2020). Research Briefing: Shop opening hours and Sunday trading
34. Trainline. Amsterdam-Hoofddorp train timetable
35. National Rail. Edinburgh Waverley-Linlithgow train timetable
36. Skånetrafiken. Malmö C-Lund C train timetable
37. Skånetrafiken. Tickets
38. Pucher and Buehler. City Cycling
39. Claris, Thorpe and Sun (2021). All Aboard… For Everyone?
40. ScotRail. Alcohol Ban
41. Mackett, R (2019). Mental health and travel: Report on a survey. UCL
42. APPG Left Behind Neighbourhoods (2021). Connecting communities: Improving transport to get 'left behind' neighbourhoods back on track
43. DfT (2012). Anti-social behaviour on public transport: Safety measures
44. Drinkaware. Drinking alcohol in public places
45. Imperial College London (2020). Women 10% more likely than men to report feeling unsafe on city public transport
46. YouGov (2020). Most women have been sexually harassed on London public transport
47. Intelligent Energy Europe (IEE) (2010). Railway Station Design
48. Design Council (2020). Think Station
49. Network Rail. Station Design Guidance
50. Network Rail Improving our stations
51. ArchDaily (2013). Barneveld Noord by NL Architects
52. UIC (2019). Railway Stations: Boosting the City
53. Apex Insight (2016). La Poste rolls out parcel lockers at SNCF stations
54. Transport Scotland. Signage
55. Cycling UK (2019). Williams Review of Britain's Railways: A response from Cycling UK
56. Vandersanden. Colourful public space in railway zone Helmond
57. Falco. FalcoCrate bike rack
58. ProRail. Bicycle parking at stations
59. ProRail (2021). New bicycle shed at Tiburg station opened
60. FietsParKeur (2021). Normstellend document fietsparkeersystemen
61. ProRail (2021). New framework contract for bicycle parking system at stations awarded
62. Underground Expert. New urban trend: Underground cycle parking
63. Rail Delivery Group. National Cycle-Rail Awards 2013
64. Stirling Active Travel Hub. Stirling Active Travel Hub
65. ProRail (2021). Fruit and linden trees planted in Tricht
66. Bicycle Dutch. Coevorden station area transformation
67. Campaign for Better Transport (2016). Development around stations: Exploring international experience and lessons for the UK
68. Academy of Urbanism (2014). Holbeck Urban Village, Leeds
69. Arch Daily. LocHal
70. Leeds City Council (2016). Consultation for Holbeck Urban Village

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References

71. University of Leicester School of Museum Studies. 100 Stories of Migration exhibition

72. Visit Sweden. Stockholm Metro art

73. SWISSARTEXPO (2020). SWISSARTEXPO at Zurich Railway Station

74. Frame Agency. Building a station fit for a Queen Street

75. Spoorbeeld. The Station Scan

76. SCOPE. Disability facts and figures

77. DfT and Transport Scotland (2015). Design Standards for Accessible Railway Stations

78. Network Rail (2020). Improving access on the railway

79. Arup Foresight. Future of Stations

80. Vivion, N. (2016) Massive growth ahead as travelers consider international rail travel in Europe

81. NaviLens. Discover NaviLens: The cutting edge technology for the visually impaired

82. Railway Industry Association (2021). Passenger Accessibility: GoMedia's 'First of a Kind' Digital Innovations Win DfT Funding

83. Catapult Connected Places. Future-proofing our train stations

84. Go Ahead and Arup (2021). Future Mobility Hubs

85. CoMoUK (2017). Public Bike Share Users Survey Results 2017

86. TU Delft (2021). Insights into the bicycle-train combination: welcome on board!

87. Urban Transport Group and Steer (2021). Fully charged: Powering up the potential of e-bikes in the city regions

88. Melia and Bartle (2020). Who uses e-bikes in the UK and why?

89. Dextre, Hughes and Bech (2013). Cities for People – Copenhagen studies in urban life in Cyclists & Cycling Around the World – Creating Liveable and Bikeable Cities

90. Dynniq. CrossWalk: safe crossing for vulnerable pedestrians

91. Applied. Legible London

92. Network Rail (2020). Network Rail and Cycling UK launch partnership as a fifth of Brits say they're considering cycling for their journey to work

93. CROW. Design manual for bicycle traffic

94. Bikeitalia (2021). Finalmente Milano avráuna rete metropolitana di ciclabili

95. Cycling Embassy of Denmark. Cycle Superhighways

96. Ajuntament de Barcelona (2017). Trees for Life: Masterplan for Barcelona's Trees 2017-2037

97. Transit Oriented Development Institute. TOD

98. Danish Architecture and Design Review (2017). The Finger Plan at 70

99. New Zealand Government (2020). National Policy Statement on Urban Development 2020

100. Bloomberg CityLab (2020). Barcelona Will Supersize its Car-Free 'Superblocks'

101. RTPI (2021). New housing developments promote reliance on cars over public transport

102. The Conversation (2019). Superblocks: Barcelona's car-free zones could extend lives and boost mental health

103. Ville de Paris. The 15-minute city in Paris

104. Victoria State Government. Plan Melbourne 2017-2050

105. Bloomberg CityLab (2021). Make Way for the 'One-Minute City'

106. Here360 (2021). Sweden's one-minute city success story

107. Kim, S. (2021). The Social Justice Impact of the Transit-Oriented Development

108. Tehrani, S et al. (2019). The Color of Health: Residential Segregation, Light Rail Transit Developments, and Gentrification in the United States

109. Herbert, J. (2021). Transformation or Gentrification? The Hazy Politics of the 15-Minute City