

Arup | Urban Transport Group

Equitable Future Mobility

Ensuring a just transition to net zero transport



Executive Summary

Ensuring the journey to net zero transport delivers an equal and inclusive society

A universal and inclusive transport system that can attract new passengers and deliver a seamless user experience is critical to decarbonising transport and challenging our over-reliance on cars. Harnessing the opportunities presented by technology and emerging modes of mobility can improve the convenience, speed, and level of service with which people can plan, book, pay for, and undertake trips.

However, if the design and governance of future mobility is left to a narrow group of technology enthusiasts, there is a risk that services will be designed for some user groups and marginalise others. Excessive hype around future mobility can distract from tried-and-trusted interventions. A growing body of research is highlighting the challenges that marginalised groups face when it comes to mobility, and transport authorities have the opportunity refocus the direction of travel around equity and sustainability to ensure a just transition to net zero.

This report, jointly prepared by Arup and Urban Transport Group (UTG) is intended as a starter for collaborative discussions between authorities, operators and users about the human dimension of the decarbonisation agenda, aiming to make our future transport system available, accessible, affordable and acceptable for all.



Based on a review of international best practice through the lens of these Four A's, this study presents a checklist for assessing the role of future mobility in creating a more equitable travel experience and informing discussions about future policy, infrastructure and services. Whilst further research, collaboration, data collection and monitoring will be required to understand the impacts of future mobility on marginalised groups, it is hoped that this checklist will enable authorities to set clear aspirations and work together with future mobility providers to facilitate the shift towards low-carbon transport options, whilst reducing inequality.

Equitable Mobility Checklist:

Category	Actions
Fair Governance and Funding	1. Set standards for future mobility
	2. Equitable funding allocation
	3. Use foresight and proactive governance
	4. Deliver fair multi-modal pricing
	5. Influence land use planning
	6. Show Political Leadership
Collaborative Ways of Working	7. Create a diverse workforce
	8. Be collaborative
	9. Co-create, consult and revise
	10. Take an intersectional approach
	11. Sustainable transport hierarchy
Inclusive Infrastructure	12. Introduce mobility hubs
	13. Mode segregation
	14. Slower spaces, better places
	15. Maintain high standards
	16. Data-driven decision making
	17. Representative data
Representative Data	18. Promote open data
	19. Develop inclusive KPIs
	20. Trial instead of error
	21. Use multiple channels
Open to All	22. Recognisable branding
	23. Respecting all users
	24. Inclusive user experience
	25. Challenge stigmas

Introduction

Transitioning to net zero transport

Transport is the biggest source of UK carbon emissions. Overall domestic greenhouse gas (GHG) emissions have fallen by 44% since 1990, however transport emissions have only decreased by 5%¹. Transport is now responsible for the largest share of domestic GHG emissions, at 27% in 2019, with 91% of this from road transport.

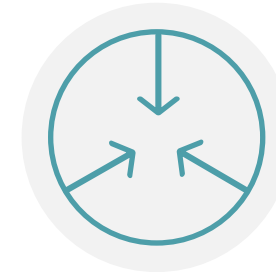
The UK was one of the first countries in the world to establish legally binding carbon emission reduction targets, in the 2008 Climate Change Act². This mandated emission reductions of 80% by 2050. In 2019, the Committee on Climate Change recommended that this be extended to a Net Zero greenhouse gas emissions target for 2050 in order to meet the commitments under the Paris Agreement³. This recommendation was incorporated into law as an amendment to the 2008 Climate Change Act in June 2019⁴. The Transport Decarbonisation Plan was published in July 2021 and sets out the roadmap for the UK to deliver a net zero transport system by 2050⁵

Decarbonisation of transport requires an improved, universal transport system that can attract new passengers, and reduce emissions. Future mobility (such as e-scooters, ridesharing, mobile apps,

mobility hubs, and ticketing innovations) has the potential to make our transport systems better and improve accessibility for all groups. However, if the design and governance of new technology is left to a narrow group of technology enthusiasts, there is a risk that services will be designed for some user groups and marginalise others, or that operators will seek to maximise revenue and profits rather than ensuring future mobility services are inclusive for all members of society.

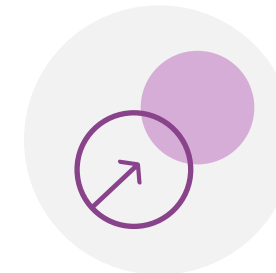
The ‘Avoid, Shift, Improve’ framework is a useful tool to prioritise attention and investment around transport decarbonisation⁶. Whilst we must consider measures to address all three, it is important to apply an inclusion lens: are some groups able to avoid travel (e.g. by working from home) more than others? Are alternatives to private car trips fully accessible for all? Who are we aiming to improve our transport vehicles and systems for?

This report, jointly prepared by Arup and Urban Transport Group (UTG) aims to start a conversation about how we ensure our future transport system is available, accessible, affordable and acceptable for everyone, enabling a just transition to net zero.



Avoid

Improving land use planning & 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 role of future mobility in delivering equitable transport

The connection between transport and social inclusion is well established. Poor access to transport services makes goods and services inaccessible, marginalising those without access to a car. These inequalities exist within our transport system, even before new technologies and business models are introduced and are exacerbated by social disadvantage. Additionally, the ability to use technology to access transport services, or access jobs and services remotely, is amplifying inequality. Transport, social and digital disadvantage can all contribute individually to exclusion, but combined, the effects are magnified, constraining a person's ability to access life opportunities.

The transport industry is currently experiencing disruption and innovation from a range of new mobility modes, services and business models. Emerging mobility patterns are being shaped by a growing industry of technology-enabled, on-demand service providers offering ridesharing, car-sharing, micro-transit and micromobility services that have disrupted not just transport service provision, but the convenience, speed, and level of service with which customers can plan, book, pay for, and undertake trips.

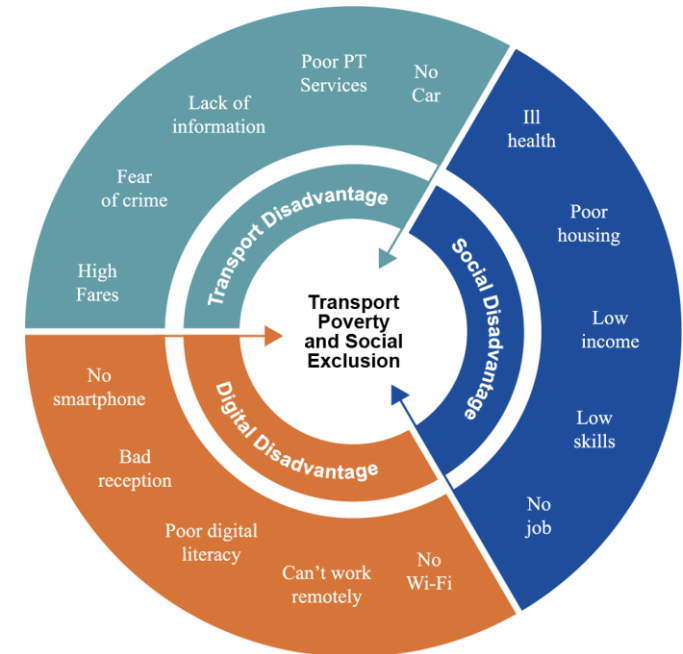
In future, our transport needs could be met by a range of mobility services, with Mobility-as-a-Service (MaaS) apps and supporting infrastructure

for charging, docking and interchanging between services improving the customer experience and integration of utilising various modes, and challenging traditional models of car ownership.

Embracing future mobility will play an important role in decarbonising transport and can help cities and towns on the journey to net zero emissions. But steps must be taken that transport is equitable – it must work for the benefit of all and contribute to social justice and levelling up, without marginalising some groups or reinforcing existing inequalities.

A transition to a net zero transport system, enabled by future mobility, must be done in a way which addresses all aspects of sustainability rather than a narrow focus on decarbonisation. The UN Sustainable Development Goals (SDGs) recognise that measures to decarbonise must go hand-in-hand with strategies that reduce inequality and social exclusion. A just transition will focus on delivering the transport needs of everyone, particularly those who are already marginalised.

Transport authorities, government and operators all play a crucial role in ensuring a just and inclusive pathway. These groups must work collaboratively to ensure that emerging transport services and technology integrate with existing systems and align with wider strategic priorities for people and places.



Adapted from the original image of transport and social exclusion⁷ with addition of digital disadvantages.

Avoiding design of transport systems for 'reference man'



Traditionally, transport systems have been skewed towards the experiences and travel patterns of the so-called 'reference man', that is a 20–30-year-old, white male in good physical and financial health, and in full-time employment⁸. This focus is connected to the data that is collected about journeys, the way that transport projects are appraised and the composition of the transport workforce, particularly at decision making level.

Transport data collection – and subsequent design of services – has historically focused on the busiest 'peak periods' of movement, seeking to improve the flow, capacity and speed of transport within the AM and PM commuting peaks, with less attention given to those who have different purposes to travel or who travel at different times of the day. The way transport projects are appraised and the criteria for funding also frequently reflects this, focusing on journey time savings, for example, rather than inclusion considerations. Decisions on the design of transport systems are often made by those in relatively fortunate and influential positions, who may not be exposed to a range of perspectives and experiences outside of their own and those of their peers⁹.

When designing future transport systems, it is important to recognise and take an intersectional approach, moving beyond thinking about equality issues singularly and considering the overlaps of a person's identity (e.g., gender, race, income, geography). Interventions to address inclusion for one group, often simultaneously benefit people with other protected characteristics. There are considerable overlaps between the challenges that marginalised groups face in accessing transport and mobility services. Designing for marginalised groups and those that face multiple levels of social exclusion will benefit all users.

There is growing awareness in the sector of gaps in data and in understanding of the lived experiences of different groups as well as the need to review appraisal methods to better serve the goal of a just transition to net zero. Transport organisations also recognise that their workforce, including at the most senior level, must better mirror the communities that they serve.

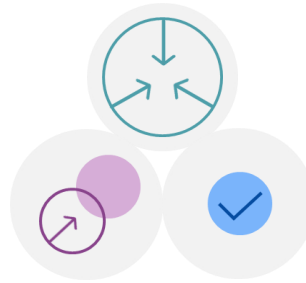
Our approach

This report takes a broad view across the spectrum of mobility services, to include new modes of transport, but also new business models and supporting technology that enhance existing modes, improve the user experience and better connect people and places.

The report considers measures to improve the availability, accessibility, affordability and acceptability of mobility services, collectively known as the Four A's.

The report provides a framework for more equitable decision making in the delivery of future mobility, aimed at helping transport authorities, operators and stakeholders make decisions which contribute to a rebalancing of the scales of social exclusion whilst addressing social, environmental and economic sustainability goals.

This report does not provide a comprehensive list of the impacts of all future mobility, but instead gives an initial view on ways in which future mobility can be designed and planned to meet the Four A's. Further research, collaboration, data collection and monitoring will be required to fully understand the impacts of future mobility on marginalised groups. This report is intended as a starter for collaborative discussions between authorities, operators and users about the human dimension of the decarbonisation agenda.



Conceptualise

The first stage of the project involved defining our scope, aims and objectives collaboratively. We identified use of the 'Avoid, Shift, Improve' framework to intersect the dual challenge of making transport more sustainable and equitable. A literature review of future mobility case studies and future scenarios considered initiatives within each of these categories for further analysis.



Workshop

We held a workshop with officers from UTG member organisations to learn about the challenges and opportunities they are facing in implementing future mobility. The Four A's categorisation was identified as a useful way to assess how transport interventions such as new infrastructure and service patterns impact equity.



Case studies

International case studies of successes and challenges of integrating future mobility modes, packages and infrastructure were examined and assessed across the Four A's. By looking at case studies in real cities, stories of successful introduction of measures and unintended consequences are used to inform recommendations for UK city regions.



Checklist & Recommendations

Throughout the report a range of recommendations are made for avoiding the pitfalls and capturing the full benefits of future mobility in terms of the just transition to a decarbonised transport system. A checklist has been designed to be used as a starting point to inform discussions between transport authorities and operators about future mobility.

Equitable Future Mobility: the Four A's Assessment Framework

In ensuring future mobility, or indeed any transport service, product or infrastructure, contributes to equity, the Four A's, developed by UTG, provide a useful framework¹⁰. Transport, including future mobility modes, services and infrastructure should be:

Available: within easy reach of where people live and enable them to access the places they want to go, at times and frequencies that correspond to patterns of family, social and working life. Services should take account of differing levels of digital literacy and access to devices. People also need to be aware that these services are available for them to use.

Accessible: as far it is safe and possible to do so, everyone regardless of ability, age or dexterity (for example), is able to use and understand the service, vehicles or infrastructure without unreasonable difficulty.

Affordable: people should not be 'priced out' of using services and see their mobility restricted as a result. It should also be easy for people to find and access a range of transport options that meet their needs and offer the best value.

Acceptable: People should feel that transport services

and infrastructure are equipped to meet their needs as well as welcoming, safe and convenient. Services should be designed to make for an attractive user experience.

Further guidance on use of the Four A's framework for assessing transport systems is provided on the next page. This includes a non-exclusive set of questions within each lens, as well as overarching considerations in applying the framework.

This report uses each of the Four A's as a lens to explore various national and international case studies for introducing future mobility.

A review of these case studies, and their impact on various user groups has identified actions which transport authorities should consider when embedding new modes and models into their mobility systems. These actions are presented as call-out boxes throughout the case studies, and are summarised in the report's conclusion. Whilst each is highlighted in one of the Four A's, most of the actions span several of the case studies. There are likely to be additional measures to implement, and local adaptations depending on context, but the actions provide a starting point for approaching the just transition.

The Four A's Assessment Framework



Areas of action on subsequent pages are shown in this format

Equitable Future Mobility: the Four A's Assessment Framework

Applying the Four A's Assessment Framework

This table contains some guidance on applying the Four A's framework in assessing transport, although not all questions will be applicable in each case.

Available	Accessible	Affordable	Acceptable
<ul style="list-style-type: none"> - Is it within easy reach of where people live? - Does it take them to the places they want to go? - Does it operate at times that fit patterns of family, working and social life? - Does it support trip chaining? - Is it easy to find out about the service, including how, when and where it operates? - What alternative options are there? - Is the service integrated with the wider transport network? - Is storage, charging and parking available? 	<ul style="list-style-type: none"> - Are there physical barriers to use (e.g. steps, small text, lack of areas to rest, no toilets)? - Is it easy to understand how to use it? - Are any particular skills or knowledge required to use it (e.g. numeracy, digital literacy, familiarity with Highway Code)? - Is any training or confidence building activity required? - Does it accommodate 'encumbered travel'? (e.g. travel with children, shopping etc) - Does it require an internet connection/smart phone/app/digital device? - Does it affect the accessibility of other modes? (e.g. create street clutter) 	<ul style="list-style-type: none"> - Is pricing as simple and consistent as it can be? - Are price rises kept to a minimum? - Are prices capped? - Is it easy to find the best value option? - Does it require a bank account? - Are different payment options available (e.g. cash, SMS, instalments)? - Are there any barriers to accessing the best value deals/transport options (e.g. digital only, large upfront costs)? - Does it require the purchase of any equipment in order to use it (e.g. a cycle, a helmet, a smart device)? - Is help available to meet or mitigate the costs of the scheme/purchasing vehicles/equipment? (e.g. grant to switch to EV, cycle library) 	<ul style="list-style-type: none"> - How does it compare to alternative options? - Is it convenient? - Is it welcoming? - Does it afford those who use it dignity and respect? - Is it clean? - Is it comfortable? - Does it feel safe? - Is it safe? - Is help available if needed? - Does marketing and branding reflect diversity and avoid stereotypes? - Is it attractive? Do people want to use it?

When considering the questions it may also be useful to:

- Ask yourself 'for whom?' For whom is it safe? Who might feel less safe? Who can afford this service? Who cannot?
- Take an intersectional approach, considering a wide range of characteristics and how they might impact on one another (e.g. age, ethnicity, gender, income, disability etc).
- Be aware of how your own experiences and privileges may affect your judgement.
- Ask people what they want and work together to come up with solutions with the help of people with professional expertise.

Available

Socially inclusive mobility should be within easy reach of where people live and enable them to access the places they want to go, at times and frequencies that correspond to patterns of family, social and working life. Services should take account of differing levels of digital literacy and access to devices. People also need to be aware that these services are available for them to use.

A

Exploring Case Studies through the Four A's

How can we make future mobility more Available?

Increasing the range of transport modes available to individuals increases the likelihood that there will be a suitable and attractive option for them. New and emerging modes of mobility can improve transport availability. How mode options are made available locally should depend on the existing transport baseline, improving availability in areas underserved by existing modes, or where household car availability is low.

Equitable Micromobility

Micromobility refers to a range of personal, small, lightweight, human or electric powered vehicles. Shared forms of micromobility can extend the reach of public transport networks by providing alternatives to walking for first/last mile trips and providing alternatives to mass transit during times of low frequency, disruption to services, or to suit weather conditions.

International experience indicates that the placement of shared transport, like e-scooters and bikes, is not always equitable. Availability of public and shared transport tends to be concentrated in city centres, where transport options are already plentiful, rather than more peripheral or disadvantaged areas. A study of e-

scooters in Paris identified that users are mostly men, aged 18–29, with a high educational level¹¹. Studies in Austin, Texas identified that minority groups experienced fewer opportunities to use e-scooters, particularly transit-dependent people and those within areas with a higher proportion of ethnic minority residents^{12, 13}.

Take an intersectional approach: This involves recognising the multiple dimensions that constitute an individual's identity - e.g., gender, race, ethnicity, age, sexual orientation, and socioeconomic status, and designing transport systems that are welcoming to all.

Planning authorities in St. Louis, Missouri have intervened to ensure equitable placement of docking stations. They require e-scooter companies to make 20% of their fleet available in targeted underserved neighbourhoods and provide an option to pay in cash to ensure e-scooters are still available for those without smartphones. Initial data is showing a large amount of ridership and comparatively longer trips from these targeted areas¹⁴.

Several operators in the UK trials are working

with authorities to improve access for women and in disadvantaged communities, highlighting the value of effective and collaborative procurement policies. Improved understanding of spatial access to micromobility, such as those collected during trials, can support ongoing efforts to deliver equitable transport systems, improve alternatives for disadvantaged populations, and support policy decisions around future mobility.

Trial instead of error: Trials of new transport services and infrastructure, such as the current UK trials of shared e-scooters, can allow the collection of real-world data to establish consensus and understand the impacts on marginalised groups.

Demand Responsive Transport

Innovative approaches are required to serve places that are not attractive to 'big tech' companies to ensure they have the flexible transport options afforded by future mobility. DRT services, such as Fflecsi buses developed by Transport for Wales can collect and drop off users closer to home than traditional bus services. This can enhance transport availability for disabled people and users in rural and suburban areas.

A

Exploring Case Studies through the Four A's

How can we make future mobility more Available?

Demand Responsive Transport (continued)

Mobility service Tandem makes use of existing taxi and minibus fleets to provide shared mobility in poorly served areas. It allows people to make and pay for a booking via an app, choosing from 20 minute slots, encouraging people to travel at the same time as others. Passengers are then matched to the right sized vehicle (depending on how many people have booked the same slot and want to make similar journeys) dispatched from existing taxi and minibus fleets. Unlike a bus service, if there are no passengers, no vehicle is dispatched¹⁵.

Set standards for future mobility: Transport and local authorities can set high standards for inclusivity and service coverage which private operators must comply with in order as part of their license to operate.

Improving Availability with Mobility Hubs

In combination with Mobility-as-a-Service (MaaS) apps, mobility hubs can provide seamless interchange between shared transport modes that can provide lower cost alternatives to car ownership. Opportunities to park or dock e-scooters, e-bikes and bike-sharing should be

located across city regions, including central districts and peripheral areas, to prevent disadvantaging certain groups. In Berlin, Jelbi stations are being rolled out in the city's suburbs, supplementing public transport within areas where frequencies are lower.



Introduce mobility hubs: Mobility hubs can extend the reach and availability of public transport. Consideration should be given to prioritising economically disadvantaged areas, where car ownership is often comparatively lower.

Cycle Storage Availability

Those living in overcrowded or high-rise accommodation do not always have storage space for cycles and e-bikes. The City of Edinburgh has many historic, multi-storey tenement buildings, leaving residents without lifts with only narrow stairwells, unable to store bicycles and larger e-bikes which help navigate the city's hills.

Sustrans installed secure 'bikehangars' in several locations around the city, each replacing a single car parking space with space for up to six bikes, presenting a space-efficient and secure solution to cycle-parking¹⁶. Residents pay £6 a month which covers maintenance and management of the sheds. Whilst this is a relatively low fee, particularly when compared with the cost of car parking, this is an additional cost for those on low incomes, particularly if the household have several cycles to park. Schemes to subsidise this cost for deprived neighbourhoods or low-income families could be explored as a way to make cycle-parking available to more users. Elsewhere in Scotland, Housing Associations are looking to convert unused drying rooms in tower blocks into secure storage for mobility devices¹⁷.

A

Exploring Case Studies through the Four A's

How can we make future mobility more Available?

Improving Availability for Older People

A study by Age UK found that 1.45 million of those 65 and over in England find it difficult to travel to hospital¹⁸. The development of new platforms, such as mobile phone apps, to support the 'social economy' could facilitate greater peer to peer transport provision, prevent social isolation later in life, and ensure access to essential services. Furthermore, if designed with an array of potential customers in mind the increasing use of assistive technology in cars, telematics in determining insurance premiums, and potentially driverless cars, could enable older people to continue driving safely for longer.

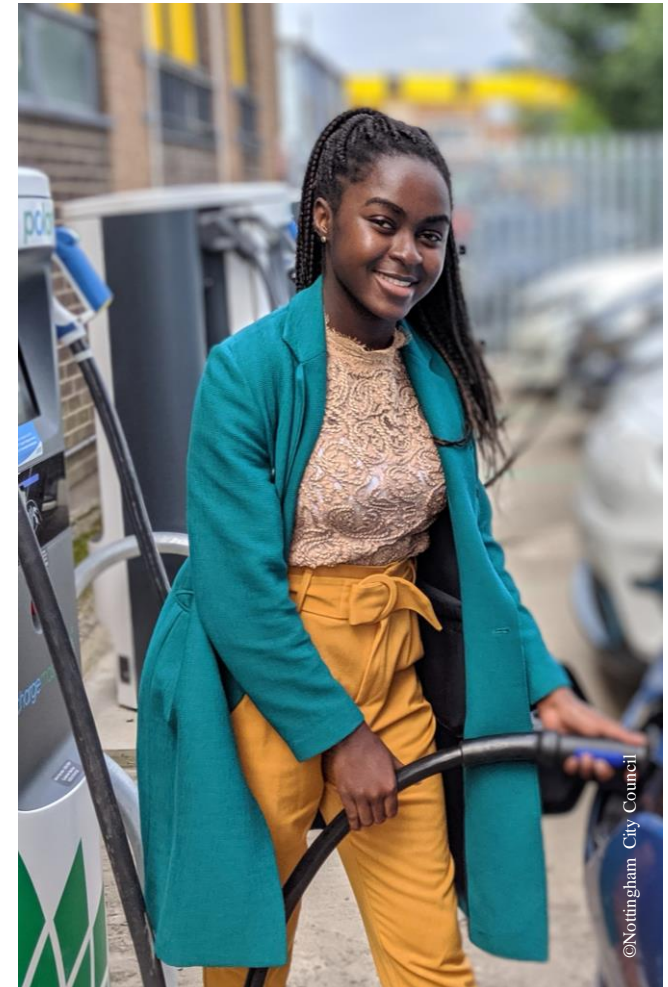
Representative data: Collecting data on the transport movements of all groups can avoid inequitable decisions. Purposefully collecting data on the movements and experiences of older people can ensure that future transport decisions are made with their mobility patterns and needs in mind.

Regional Disparities in EV Charging

London and the South East, some of the country's most affluent areas, are by far the best served by EV charging infrastructure¹⁹. It could be argued that this installation is not according to need, since London has a strong public transport network and transit-oriented development means that private vehicles are often not needed to reach essential services.

Part of the reason behind this inequitable distribution of EV charging infrastructure is that it is broadly market-led, with individual business and affluent individuals funding the infrastructure. A local-authority led approach could promote EV charging infrastructure where it is most needed, or is unlikely to be funded by other means, and where there are few alternatives (e.g. rural/out-of-town developments). Shared models such as EV car clubs can improve the availability of low emission vehicles for those without access.

Data-driven decision making: New technologies offer the opportunity to put robust data at the heart of decision making. Better data could ensure that charge points and other infrastructure are introduced where need is greatest.



Accessible

As far it is safe and possible to do so, everyone regardless of ability, age or dexterity (for example), is able to use and understand the service, vehicles or infrastructure without unreasonable difficulty.

A Exploring Case Studies through the Four A's How can we make future mobility more Accessible?

Future mobility modes and services should be accessible by design and can be enhanced by complementary digital technology. Though caution should be used in relying on personal technology to navigate transport systems to avoid an inadequate user experience for those without smartphones, for tourists and other infrequent users not wanting to set up new online accounts, and instances of mobile devices running out of charge.

Inclusive Digital Ticketing

With the move towards future mobility, the option to buy tickets from members of staff, ticketing machines or offices is being lost to the detriment of marginalised groups. In the UK, whilst around 96% of 16-24 year olds own a smartphone, only 78% of those over 55 years old own one²⁰. Owning a smartphone does not guarantee access to future mobility services. A case study across the UK revealed reception problems and evidenced older age groups being uncomfortable and anxious about online transactions²¹ [23]. Non-digital

ticketing alternatives should continue to be made available in order to avoid exclusion. Other measures to improve the accessibility of ticketing could include allowing payment by SMS (with payment added to mobile bill) rather than requiring users to have a bank account. In some cases, tickets are cheaper or there are additional discounts available for app users, which unfairly penalises those without smartphones or users that prefer to use kiosks to purchase their tickets. There should be no financial penalty for wanting to purchase a ticket outside of an app.

Use multiple channels: There should always be the option to navigate, purchase tickets, and report instances through several channels so that all users can access information and support.

Passenger Assistance

In order to make public transport accessible for disabled people, assistance is sometimes required. The Rail Delivery Group have developed a 'Passenger Assistance' app, enabling disabled passengers to book assistance on their train journeys via their phones, and to be

able to update any bookings on the go²². The app was developed in collaboration with rail companies, an Accessibility panel and accessibility experts, demonstrating the role of cocreation of future mobility solutions.

Co-create, consult, revise: Collaborative working across organisations and early consultation with users about new modes of transport and technologies helps to ensure the transport system is accessible for all users.



A

Exploring Case Studies through the Four A's

How can we make future mobility more Accessible?

Inclusive Micromobility

As highlighted previously, micromobility can extend the availability of transport services. However, dockless micromobility, not requiring the use of a defined station at the start/end of rentals, can infringe on pedestrian space and cause difficulty for disabled people, impede transport accessibility for some groups.

Be Collaborative: Authorities will need to be agile, collaborative and responsive to new innovations in setting regulations and designing infrastructure for micromobility to improve the safety and comfort of all road users.

Electric Assistance Improves Accessibility

Opportunities should be taken to use e-bikes and e-scooters to improve the accessibility of transport for disabled people or those with lower fitness levels. Electric assist can support people to make longer journeys than on non-electric models, widening their transport horizons. Adapted cycles should also form part of shared schemes to further enhance accessibility.

In addition, mobility scooters aid older people to maintain their independence, but uptake is low,

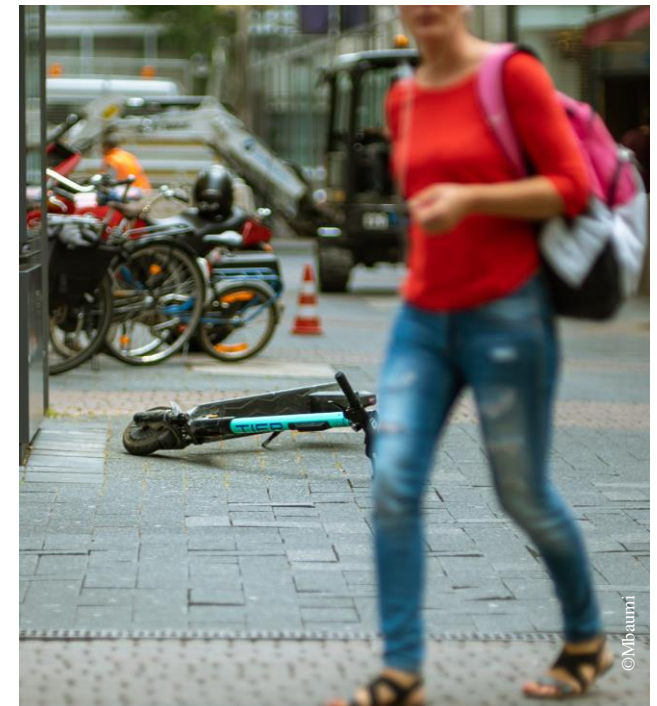
partly due to the stigma around their use, and difficulties in storing them. New models of mobility scooters present an opportunity to design to overcome barriers to mobility for older people, reducing isolation. With ageing populations, there could be an opportunity for MaaS services to include mobility scooters within the vehicle offering so that older people using public transport to town centres can continue their onward journey with mobility scooters.

Challenging stigmas: Changing negative perceptions through innovation and inclusive design helps to make shared mobility services attractive to all.

Improving e-scooter safety

Within the UK e-scooter trials, transport authorities including Transport for London (TfL), have taken a proactive approach in setting out a robust safety specification as part of the tender process for operators. The specification for e-scooters ensure that they are more sturdy, and have identification plates to help with enforcement and avoid dangerous or illegal behaviour. TfL are collaborating with operators to

provide safety training and information events, targeted at first time riders²³. These measures improve the acceptability of e-scooters for users and non-users. Several operators are integrating new technology to improve the safety of e-scooters, such as detecting when riders are unlawfully riding on pavements.

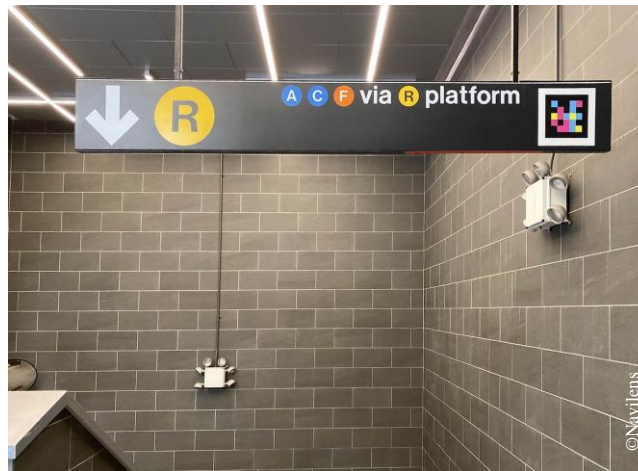


A Exploring Case Studies through the Four A's How can we make future mobility more Accessible?

On board Audio-Visual Announcements

On board audio-visual announcements on public transport and public transport apps can improve accessibility for people with visual or hearing impairments as well as for users more broadly, particularly those who are new to a route or are occasional users. Multiple methods of communication should be used and updated in real-time. Removing a channel of communication will make systems less accessible and increase stress and discomfort for various user groups. Alongside on board visual messages, digital apps can help to improve communication. These apps can be available in multiple languages making a transport network more accessible for tourists, international students, and migrants where there is a language or cultural barrier. NaviLens introduced simplified QR codes that can be scanned 12 times further away than QR and barcodes via a mobile phone to improve the experience of using public transport for visually impaired users. The codes deliver information through earphones about the location of lifts, platforms, escalators and information desks,

aiding navigation. The app has been successfully used in the New York Metro system to help users be more independent in new spaces and avoid any discrepancies between the information they and other users receive²⁴.



Maintain high standards: Marginalised users come to rely on certain technologies, aids and infrastructure. A maintenance plan should prioritise their immediate repair.

Accessible Electric Vehicles

Currently there are very few EVs on the market that are suitable for disabled people. This is predominately due to the 'skateboard architecture' of EV design. The battery pack, the electric drivetrain, and the electrical architecture all rest under the floor of the vehicle, making it difficult for disabled users to get in as it raises the height of the vehicle²⁵. There are also concerns over the accessibility of charging. A survey by the Research Institute for Disabled Consumers (RiDC) found that 61% of disabled people would consider buying an EV if it was made more accessible. The inaccessibility comes from the need to manoeuvre around charging points, the need to carry heavy cables, and that charging bays are not typically designed with the additional space needed for disabled drivers and passengers²⁶.

Respecting all users: Ensure that services delight the customer and treat all users equally. Design services that respect the dignity of users with specific needs from the outset, rather than treating this as an add-on.

Affordable

People should not be 'priced out' of using services and see their mobility restricted as a result. It should also be easy for people to find and access a range of transport options that meet their needs and offer the best value.



Exploring Case Studies through the Four A's

How can we make future mobility more Affordable?

Affordable Fares and Ticketing

The cost of transport influences access to opportunities – people should not be placed at a disadvantage due to the unaffordability of transport options. 40% of jobseekers say lack of transport is a barrier to getting a job, and almost half of 16–18-year-olds experience difficulty with the cost of transport to education²⁷. High transport costs are a barrier for accessing essential services, grocery stores and GPs. People without cars find it more difficult to access reasonably priced food and 16% of people without cars find getting to a supermarket difficult²⁸.

Different forms of payments methods and ticketing options should be available to meet the needs of different users. Discounts for young, old, unemployed and low-income individuals and families should be included in transport and mobility services. Rather than individual prices on a mode-by-mode basis, a shift to thinking about door-to-door journeys can increase transport affordability. Integrated ticketing, subscription bundles and capped fares can reduce

the burden of individual ticket purchase. The inability to pay large upfront season tickets should not exclude users from the best offers.

Fair Multi-modal Pricing: To reduce financial and transaction costs of multi-modal sustainable travel new ticketing options for tickets that cover several modes should be made available.

Widening Access to Affordable Shared Transport

Cheaper public transport prices are often gained through monthly or annual passes, yet large upfront costs mean that those in most need of reduced prices cannot access them. Similarly, the costs of car club memberships and MaaS packages can be prohibitively high. Linstone Housing Association in Paisley, Scotland, offer subsidised EV car club membership for their tenants²⁹. Many do not have access to their own car and a taxi to the nearest budget supermarket costs around £15. Car club membership is free for tenants and reduced rates mean that a two-hour trip to the supermarket would cost just £3 plus 16p per mile, a significant saving compared to taxi.

In Middlesbrough, micromobility operator Ginger has attempted to price e-scooter rental at an affordable rate, to attract a wider demographic and encourage regular, rather than occasional users. The vehicles cost £2 for 20 minutes hire (equivalent to 3.5 miles) - 62% of the scheme's users earn less than £20k³⁰.

Develop Inclusive KPIs and Open Data:

Developing KPIs such as on affordability of new mobility services as part of transport and decarbonisation strategies can improve equity and enable more inclusive decisions. Encouraging the use of open data can help to measure progress transparently and hold stakeholders to account.

A Exploring Case Studies through the Four A's How can we make future mobility more Affordable?

Electric Vehicle Affordability

Electric Vehicles (EVs) are high on the national agenda as part of decarbonisation efforts. The UK Government's 2030 ban on new sales of petrol and diesel cars and vans, and cities with Low Emissions Zones and Congestion Charging Zones are measures to promote uptake of EVs³¹. Lower running and maintenance costs mean that EVs are cheaper than conventional vehicles on a total cost of ownership basis. Indeed, it is estimated that households could save between £3,000 and £5,000 per car by switching to an EV, compared with the cheapest diesel vehicles³². However, EVs are still not affordable upfront for many consumers on lower incomes, particularly with no mature second-hand market to buy from. Typically, the price for a new EV is £4,000-£8,000 higher than its petrol/diesel counterpart³³. This further widens the living standard gap between affluent and less affluent areas. EV ownership is higher in affluent areas, reducing air and noise pollution compared with less affluent neighbourhoods still reliant on

conventional vehicles. Bolstering sales of new EVs should eventually build a more affordable second-hand market for EVs. In the meantime subsidised car clubs could widen access to EVs for more people and places.



Mobility Pricing

Findings suggest that for low-income groups, private car ownership can represent a cost equal to housing, consuming a large share of disposable income. A study in Germany found that car ownership is one of the most expensive household consumer goods, with the total

lifetime cost of car ownership (50 years) ranging from £500K for an Opel/Vauxhall Corsa to £800K for a Mercedes GLC³⁴. Motorists often underestimate the full private costs of car ownership, but the external costs (e.g. accidents, air pollution and lifecycle carbon) are rarely accounted for. The same study estimated that 30-40% of car ownership costs are born by society.

Mobility pricing represents an opportunity to internalise these costs and better reflect the full costs of private car use as well as the economic viability and environmental credentials of alternative transport modes. Revenue or taxation from such measures could be ring fenced to subsidise public and shared transport.

Equitable funding allocation: authorities must consider ways to address the rising costs of public transport and falling costs of private car use in addressing decarbonisation. The climate emergency will require investment in sustainable modes that are for all user groups, particularly those that serve areas where services are less profitable.

A Exploring Case Studies through the Four A's How can we make future mobility more Affordable?

Avoiding Expensive Upfront Costs

Shared mobility schemes, from car clubs to e-bike share, can help people to avoid the costs of purchasing, maintaining and insuring a vehicle. However, it is important that these schemes avoid high upfront costs, such as membership fees which can prevent people on lower incomes from accessing the best value transport options. Through consolidating transport options into mobility hubs and considering expanding on-demand and shared networks, communities can be lifted from unaffordable car dependency.

Create a diverse workforce: Attracting and retaining employees that represent the diversity of the communities they serve means transport authorities are more likely to be cognisant of different perspectives and challenges, such as around transport affordability.

Mobility Credits / Universal Basic Mobility

Policy measures recognising that everyone should have access to transport that meets their needs, at a minimum service level are gaining traction in relation to addressing social justice and net zero transport. As part of a Future Mobility Zone pilot in the West Midlands, drivers are paid mobility

credits to use on car-sharing, public transport and electric vehicle hire schemes as an incentive to scrap their personal vehicles³⁵. Similarly, participants in a universal basic mobility pilot project in Oakland, California receive prepaid debit card to access public transit, bikeshare, and shared e-scooters³⁶. In 2020, Luxembourg became the first country in the world to offer nationwide free public transport for everyone³⁷, whilst pilots of free public transport are planned in several European cities, including in France and Germany.

However, public transport fares can be used to subsidise services in areas where patronage is lower, so any scheme to improve public transport fares should also consider the equity components of coverage and service standards.

Carpooling / Autonomous Vehicles

There have been debates around whether carpooling (an arrangement in which a group of people commute together by car) EVs should be exempt from congestion charges. A Gothenburg operator, GreenMobility, has passed the

congestion charge on to customers (as an addition to the ride charge) when the city authorities announced that carpooling EVs would not be exempt³⁸. This debate is context specific, and should consider the strength of alternatives: are there attractive bus, tram or rail services? Public transport will have a lower carbon footprint than EVs due to their ability to carry more passengers, spread of embodied material carbon across a larger number of passengers, and optimised timetables³⁹. As shared, and autonomous vehicle business models emerge, care should be taken to ensure that services duplicating public transport are priced in an equitable way.

Use foresight and proactive governance: Anticipating potentially negative impacts of future mobility and taking a proactive approach can encourage more equitable mobility. For example, provisions in a US funding bill state that Federal funds can't be used for autonomous vehicle projects that *'duplicate, eliminate, or reduce frequency of existing public transport services'*.

Acceptable

People should feel that transport services and infrastructure are equipped to meet their needs as well as welcoming, safe and convenient. It should be designed to make for an attractive user experience.

A Exploring Case Studies through the Four A's How can we make future mobility more Acceptable?

Cycling for different users

Active travel such as cycling or walking could have health benefits and reduce isolation, however, shared schemes do not always take account of the needs of different user groups and how these can be supported to improve uptake. For example, only 8% of men and 3% of women over 65 in the UK cycle¹⁰. Governments of Denmark, Germany and the Netherlands have invested in infrastructure to create safe cycle lanes, resulting in higher rates of cycling later in life.

Shared cycles themselves are often 'one-size-fits-all'. In a survey, 48% more women than men identified travelling with groceries and bags as a challenge⁴⁰ and yet shared cycle options tend to exclude baskets as well as other helpful additions such as child seats. Women are more likely to 'trip-chain' (combining several smaller trips together, such as between home, school drop off, work and shopping), and therefore have different needs of their transport systems. Some city councils, including Dublin have installed cycle parking facilities for cargo and non-traditional cycles⁴¹ which can be used by parents travelling

with children or shopping. In San Francisco, Lyft is offering a range of cycles for disabled people, including: upright handcycles, recumbent handcycles, recumbent leg trikes, recumbent trike tandems and side-by-side tandem bicycles⁴².

Night time safety for Women

Various public transport services – particularly at night – are less acceptable to people who do not fit the 'reference man' template. In the UK, 71% of women of all ages have experienced some form of sexual harassment in a public space, including public transport⁴³. Solutions to this are needed within and beyond the scope of the transport sector.

In Kalmar, Sweden night time security has improved through night buses dropping off passengers in-between regular bus stops, which can be a way to ensure passengers are getting off where is most convenient, comfortable and safe for them. In Bolzano, Italy the "Taxi Rosa" has been introduced. This is a dedicated taxi service available to women in the evening between 8pm – 6am with discounted rates (€ 3 discount per ride). The idea is to ensure that women do not see cost or availability as a barrier to a safe ride home

rather than walking alone in poorly lit areas. The city have also introduced female-dedicated parking areas, which are easily accessible, well-lit and near exits in garages.



Slower spaces, better places: Slower traffic speeds and better infrastructure for active travel in neighbourhoods will improve local air quality and act as a catalyst for social interaction. Improvements to green and blue infrastructure and places for people can make neighbourhoods safer, healthier, more social and sustainable.

A Exploring Case Studies through the Four A's

How can we make future mobility more Acceptable?

Safety in Public Spaces

Users must feel safe when using public spaces and transport services, no matter the location or time of day. Street design plays a key role in improving safety and people's perceptions of public spaces. The introduction of new transport services, technologies and infrastructure should influence safety outcomes and contribute to vision zero agendas (zero deaths from road incidents). In addition to improving infrastructure and user behaviour, measures to avoid travel and encourage mode shift also provide opportunities to improve road safety. Research suggests that shifting car trips to public transport for example is 30-66 times safer per passenger mile, whilst also providing co-benefits for cyclists and pedestrians⁴⁴.

Technology can Improve Safety at Crossings

Road crossings do not always give adequate time to cross safely, or comfortably, without feeling rushed and stressed, particularly for parents with young children, older people and disabled people. The Netherlands have trialled Dynniq's CrossWalk mobile app which extends the green time at traffic signals when older or disabled

people approach the lights, giving them greater confidence and safety⁴⁵. The app can also help ITS systems detect groups of cyclists and school 'bike-buses', and ensure they cross the road together, aiding comfortable, social and safe cycling⁴⁶.

Improving Walkability

Improving the public realm and pedestrian crossings is a crucial step to improve pedestrian confidence. A recent survey found that 83% of adults would feel more confident in crossing the road with zebra markings⁴⁷. Greater Manchester has found that drivers give way 30% more to pedestrians when there are zebra marking versus instances without⁴⁸. Reducing vehicle speeds, better lighting and CCTV coverage, improved crossings/visibility, and accompanying technologies enabled by mobile apps and geolocation services can improve the usability and acceptance of public spaces and active forms of transport.

Sustainable transport hierarchy: Infrastructure decisions should make sustainable travel more acceptable for potential users. Continuous crossings at minor junctions for example provide priority for pedestrians over vehicles and reflect recent changes to the highway code.



A Exploring Case Studies through the Four A's

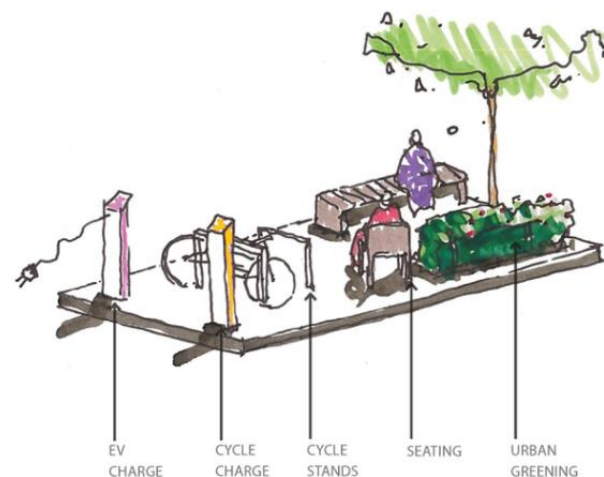
How can we make future mobility more Acceptable?

Inclusive Design of EV Charging

Location and design of EV charging is becoming a contentious issue, particularly around the lack of guidance for on-street charging. EV owners without driveways impose themselves on active travel infrastructure with cables draping across cycle paths and pavements. This poses a safety concern, and an equity concern as those walking and cycling already face infrastructure that is often too narrow and unfit for purpose. There are a range of solutions for on-street EV charging, but they vary in terms of their acceptability for other users, particularly marginalised users. Local authorities, in consultation with action groups and marginalised users, should determine the most appropriate specifications for these chargers that is acceptable for all.

ReCharge Parklet

Rather than providing EV charging infrastructure within already constrained pedestrian spaces, this concept transforms a parking bay into a space that combines EV and e-Bike charging facilities with a micro-park known as a 'parklet'. It can also provide mobile phone charging, Wi-Fi, seating, bicycle stand and pump, and urban greening. The concept is aimed at boosting levels of activity in cities by making them more attractive for walking and cycling and improving social interaction on a street.



Representation in Digital Apps

Greater attention on apps is needed to enable users to choose a service that matches their needs e.g. Shared cars with child seats and cars that are easier to get into for older people. Studies across Europe show that families with young children, are willing to transition from car ownership to car-sharing. When designing to improve user experience, it is critical to consider all possible users and not just the typical 'reference' case.

Influence land use planning: Integrating transport and land use planning can have significant impacts on demand for travel. It can also help alleviate issues such as the availability of EV charging at new developments, and contribute to a more equitable and efficient use of public space.

Inclusive user experience: Providing convenient, reliable, time information can improve people's journeys. The user experience must be inclusive at all user touchpoints including within apps, but also at booking sites, ticket offices, information boards and on board services.

Towards Equitable Future mobility

Towards Equitable Future Mobility

Ensuring future mobility enables a universal, low-carbon transport system that delivers social justice

The Four A's: What have we learned?

Exploring case studies through the lens of the Four A's has identified key areas which require intervention to ensure that future mobility enables more equal access to transport.

Whilst existing transport systems, governance, investment decisions and mobility services are often understood to be addressing social exclusion, a growing body of research is highlighting the challenges that marginalised groups face when it comes to mobility.

Technology can improve the accessibility of transport networks, and a thriving market of competing services can reduce the costs of services – but left unchecked, a focus on the bottom line is unlikely to lead to equitable service coverage, leaving gaps in the availability of services. This is not to say that private mobility operators are not purpose-driven. Many are, and continue to work closely with authorities to continuously improve the impact of their products and services.

In the context of transport, technology should be seen as a tool rather than an outcome. Excessive hype around future mobility can distract

from tried-and-trusted interventions to reduce car reliance and deliver on sustainability goals. As highlighted through exploration of the Four A's, transport authorities have the opportunity to shape the direction of travel equity, ensuring a just transition to net zero.

A Checklist for Equitable Future Mobility

Drawing upon the research and discussions with policymakers and practitioners, several actions have been identified to foster inclusivity and fairness in our future low-carbon transport system.

A checklist summarising these within the following categories is presented within this section:

- Fair Governance and Funding;
- Collaborative Ways of Working;
- Inclusive Infrastructure;
- Representative Data; and
- Open to All.



Equitable Future Mobility Checklist

Fair Governance and Funding

Delivering fair and inclusive transport services must start at the top. Transport authorities should set out a strategy and policy direction for equitable mobility to establish the ground rules for future mobility services and operators. Understanding the culture, geography and needs of users locally and shaping services to suit will be key to ensuring sustainable mobility choices are inclusive at a local level.

Action	Description
1. Set standards for future mobility	Create explicit standards to guide future mobility operators and data providers. Co-ordinate information, ticketing and branding across all vehicle modes, including micromobility for first/last mile, as part of a holistic offering to passengers.
2. Equitable funding allocation	Establish long term funding, organisational capacity and innovation required for effective mobility management, and ensuring we invest in sustainable modes that are for all user groups.
3. Use foresight and proactive governance	Use foresight to anticipate conflicts and avoid potentially negative impacts of future mobility. Shape future urban mobility around local visions for transition to net zero, rather than taking a reactive approach.
4. Deliver fair multi-modal pricing	Create ticketing and information systems (e.g. MaaS) with affordable packages for multi-modal mobility.
5. Influence Land Use Planning	Consider the impacts of land use and digital connectivity in future mobility policymaking.



Equitable Future Mobility Checklist

Collaborative Ways of Working



Seeking the views of a more diverse range of users can bring new innovative ideas and allow informed and improved decision making to ensure transport works for everyone. Collaboration and partnership working across the transport ecosystem will be required to accelerate the transition to net-zero. Designing for marginalised groups and those that face multiple levels of social exclusion will benefit all users.

Action	Description
6. Show Political Leadership	Systemic change will require strong leadership. Political leaders should acknowledge the changes required to create a fair and sustainable transport system – and practice what they preach.
7. Create a diverse workforce	Ensuring transport authorities attract and retain employees that represent the diversity of the communities they serve means access to a variety of different perspectives and can contribute to inclusive design.
8. Be collaborative	Share best practices, experiences and lessons learned on embedding future mobility between policymakers and operators.
9. Co-create, consult and revise	Involve communities in decision making processes (e.g. citizen assemblies, workshops) and use different methods and mediums to ensure all societal groups are included in consultation. Most importantly – take views on board and revise plans as appropriate.
10. Take an intersectional approach	Recognise the multiple dimensions that constitute individuals' identities - e.g., gender, race, ethnicity, age, sexual orientation, and socioeconomic status, and design transport systems that are welcoming to all.

Equitable Future Mobility Checklist

Inclusive Infrastructure

Decisions around infrastructure investment must influence positive changes to transport choices and create inclusive and liveable environments. Re-allocating road space can deliver priority for public transport and active mobility that enables faster, more attractive journeys and improves reliability. Physical and digital multi-modal connectivity can provide a seamless user experience, influencing sustainable travel behaviour.

Action	Description
11. Sustainable transport hierarchy	A sustainable transport hierarchy can help guide decision making by considering measures that first focus on the role of place in reducing trips, before prioritising sustainable modes.
12. Introduce mobility hubs	Establishing mobility hubs at the heart of communities to improve movement choices and interchange between transport modes. Improving the mobility experience by connecting seamlessly with neighbourhood services and facilities.
13. Mode segregation	Provide physical separation between modes to improve comfort and safety for all users. Improving priority and right of way for public transport and active mobility can make journey times competitive for sustainable modes.
14. Slower spaces, better places	Slower speeds in neighbourhoods will improve local air quality and act as a catalyst for social interaction. Improvements to green and blue infrastructure and places for people can make neighbourhoods safer, healthier, more social and sustainable.
15. Maintain high standards	Maintain infrastructure over time so that it continues to deliver high quality access for users. Designing flexibility and adaptability into new infrastructure is important, given the rate of technological change.



Equitable Future Mobility Checklist

Representative Data



To transition to a low-carbon equitable transport system, a wide range of data across all user groups is required to inform decision making. When developing data collection strategies, care must be taken to avoid any unintended biases. In a constantly evolving sector, data collection needs to be equally dynamic to capture changing mobility patterns.

Action	Description
16. Data-driven decision making	New technologies offer the opportunity to put robust data at the heart of decision making around mobility, land use and telecommunications.
17. Representative data	New technology and data can help create an integrated, universal transport system truly focused on delivering better services for a diverse range of customers. We should ensure data collection represents all existing and potential transport users, particularly those typically under-represented.
18. Promote open data	Promoting open and shared data policies improve the transparency of mobility decisions and can support new innovations to improve the user experience of transport systems.
19. Develop inclusive KPIs	Implementing a range of KPIs to measure progress towards the Four A's as part of transport strategies and transport decarbonisation planning to ensure that the transition is equitable, and on track.
20. Trial instead of error	Initiating trials for future mobility to learn about equity impacts which can be addressed before wide implementation.

Equitable Future mobility Checklist

Open to All

Fostering a sense of ownership amongst users can ensure that transport systems are safe and truly open to all. Through feeling knowledgeable about the services, users can carry out door-to-door journeys with ease and confidence. By making each part of the transport system inclusive (e.g. journey planning, wayfinding, ticketing, access, egress), users can be more comfortable with their mobility choices and options.

Action	Description
21. Use multiple channels	Develop methods of two-way communication with customers, not solely through digital apps to avoid digital divides.
22. Recognisable branding	Developing a consistent regional brand for public transport services and first/last mile mobility can build trust amongst passengers. Ensuring access is universal and delivers equitable outcomes can add long term brand value.
23. Respecting all users	Ensure that services delight the customer and treat all users equally. Design services that respect the dignity of users with specific needs from the outset, rather than treating this as an add-on.
24. Inclusive user experience	Providing an inclusive door-to-door user experience that meets a customer-centric value proposition should be developed to give users a high quality experience across a range of mobility services across the Four A's.
25. Challenging stigmas	Change negative or exclusive perceptions of modes and behaviours so that mobility services are attractive to all. Curating a culture of openness and communication can help social interaction and avoid users feeling unsafe or isolated.



Towards Equitable Future Mobility

Ensuring future mobility enables a universal, low-carbon transport system that delivers social justice

Continuing the conversation

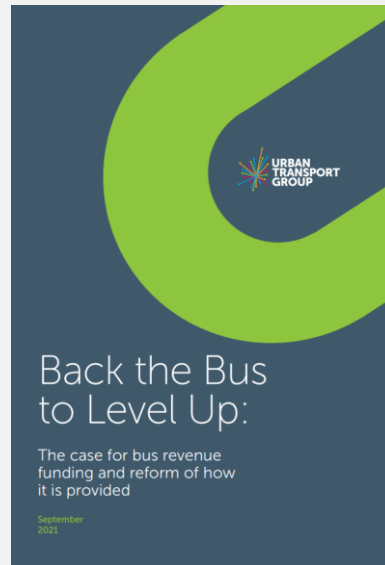
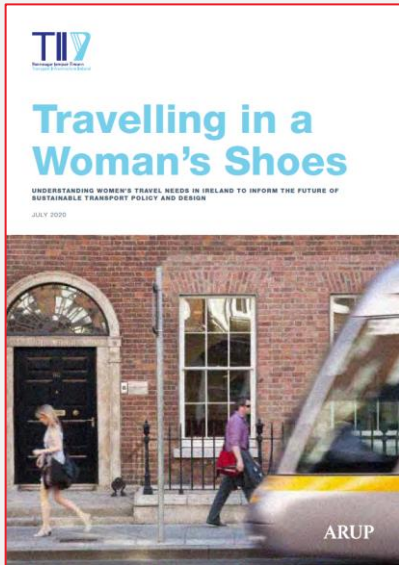
This study shows us that designing transport that people will use and love requires innovative new ideas and a new level of inclusivity in policy and practice.

Further research, collaboration, data collection and monitoring will be required to understand the impacts of future mobility on marginalised groups. Authorities, government and operators all play a crucial role.

Whilst the most appropriate actions will vary from one authority to another, it is hoped that the checklist provides a starting point for authorities to set clear aspirations, and work together with future mobility providers to facilitate the shift towards low-carbon transport options, whilst reducing inequalities.



Further reading and guidance on transitioning to equitable transport systems



To support the checklist for delivering equitable future mobility, Arup and UTG have worked on a number of research reports across modes and geographies to provide more targeted advice for urban transport transitions.

- [Travelling in a Woman's Shoes](#) – Arup & Transport Infrastructure Ireland
- [Back the Bus to Level Up](#) – UTG
- [Cycling for Everyone](#) – Arup & Sustrans
- [Tomorrow's Public Transport System](#) – Arup
- [Making rail reform work for people and places in the city regions](#) – UTG
- [Queering public space](#) – Arup & University of Westminster



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Get in Touch

Arup is a global firm of designers, planners, engineers, architects, consultants and technical specialists. Our primary goal is to develop a truly sustainable built environment. This means that in all our work, we aim to identify a balance between the needs of a growing world population and the finite capacity and health of our planet. We have co-developed this research with the Urban Transport Group (UTG), the UK's network of city region transport authorities, working to ensure that transport plays its full part in making city regions greener, fairer, happier, healthier and more prosperous places.

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