Asia-Pacific
Economic Cooperation

Improving the Accessibility and Inclusivity of Public Transport through New and Emerging Transport Technologies

Best Practice Guidance for Policy Makers

APEC Transportation Working Group

July 2024

Asia-Pacific
Economic Cooperation

Improving the Accessibility and Inclusivity of Public Transport through New and Emerging Transport Technologies

Best Practice Guidance for Policy Makers

APEC Transportation Working Group

July 2024

APEC Project: TPT 07 2023S

Produced by
The Centre for Technology Infusion, La Trobe University
Heloise Campbell
Lenny Mammoliti
Erik van Vulpen
e.vanvulpen@latrobe.edu.au

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

APEC#224-TR-01.2

iMOVE project 6-022 - This research is funded by iMOVE CRC and supported by the Cooperative Research Centres program, an Australian Government initiative.

List of Abbreviations

AHRC	Australian Human Rights Commission
APEC	Asia-Pacific Economic Cooperation
ACC	Augmentative and alternative communication
CRPD	UN Convention on the Rights of Persons with Disability
DITRDCA	Department of Infrastructure, Transport, Regional Development, Communications, and the Arts (Australia)
DPO	Disabled People's Organisation
IIEG	Intermodal and Intelligent Transportation Systems Experts Group
MDI	Mobility Divide Index
NDS	National Disability Services (Australia)
OHCHR	Office of the United Nations High Commissioner for Human Rights
PPP	Public Private Partnerships
ROD	Return on Disability
TRIPS	Transport innovation for People with Disabilities needs Satisfaction.
UNDESA	United Nations Department of Economic and Social Affairs
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
US DoT	United States Department of Transport
UD	Universal Design
WB	World Bank
WHO	World Health Organisation

Contents

1. Background 5
2. Introduction 6
3. Policy development best practices and resources 7
   3.1 Understand the problem and set objectives 8
   3.2 Commitment: Re-energise institutional commitment 13
   3.3. Standards and regulations 19
   3.4 Technology opportunities to improve accessibility 22
   3.5 Collaboration 30
4. Conclusions 34

Helpful resources: 36
Bibliography 40
Image references 44

1. Background

This project has been undertaken as part of APEC's Intermodal and Intelligent Transportation Systems Experts Group (IIEG) main policy theme of Improving Accessibility and Inclusivity in the Use of New and Emerging Transport Technologies. This document is the result of a partnership between La Trobe University's Centre for Technology Infusion, the Australian Department of Infrastructure, Transport, Regional Development, Communications, and the Arts (DITRDCA), and the IIEG.

The objectives of the project were to:

- Identify current barriers to transport access for people with disability.
- Identify hurdles and opportunities for new and emerging transport technologies.
- Set up an expert group to start collaboration between APEC members.
- Highlight common barriers to adopting assistive technologies across economies.

Through workshops conducted with APEC member economies, we have identified that the primary barriers hindering the adoption of technological opportunities to enhance public transport stem from inadequate funding and a scarcity of relevant data.

In this report, we have collated international resources to help address these and other potential issues to advance the adoption of accessible technology solutions for public transport. The aim is to give an overview of technology case examples, as well as to provide practical steps and resources for policy makers to support the adoption of new emerging technologies to enhance access to transportation.

2. Introduction

As cities and regions become more populated and complex, there is a growing awareness of the need for economies to deliver transport equity – that is, to provide everyone with the same access to reliable, affordable transport. This improves quality of life and brings economic benefits to the general economy because people who can access public transport are more likely to work and travel.

An estimated 1.3 billion people in the world experience significant disability, or roughly 16% of the population. While technology is not the solution to all barriers and challenges, new transport technologies can significantly improve mobility outcomes for people with disability and older people.

Developments in technology such as microcomputing, artificial intelligence (AI), connectivity, and battery technology are driving rapid advancement in improving transport outcomes. These have also led to the emergence of new technology solutions to help those with disabilities overcome barriers in accessing transportation, and thereby gain greater autonomy and independence.

Stephen Hawking pioneered the use of technology to overcome his communication barriers. His remarkable use of his cheek muscles and eyes to communicate and write books using a high-tech communications aid has earned widespread admiration. Today, such augmentative and alternative communication devices have become mainstream and can greatly improve quality of life for many.

Similarly, other innovative technologies have also become available for a wider audience. Technologies such as navigation and trip-planning apps, automated wheelchairs, iBeacon signage, smart glasses and canes, frictionless ticketing, and aids for human-machine interaction, can lead to significant improvements in accessibility for a wide spectrum of people with disability. That is, if they can afford the technology. In many economies people with disability have financial constraints.

Developed under the auspices of the APEC IIEG, this best practice guidance material includes case studies for incorporating new technologies into transport policies. This report provides a framework that encourages a shared view on overcoming the main impediments to assistive technology uptake, with the intention of encouraging collaboration and knowledge sharing between economies.

While accessibility experts may find themselves in familiar territory, for others, we hope that this document provides a useful overview of actions and resources to help drive innovation in such an important aspect of life for people with disability.

3. Policy development best practices and resources

Like any complex problem, adopting new technologies to improve accessibility and inclusion for people with disability in public transport requires activity across multiple interlinked focus areas.
Policy development starts with a clear understanding of the problem and setting clear objectives, but an effective policy also requires:

- institutional commitment
- up-to-date standards and regulations
- a thorough understanding of the latest solutions
- collaboration with people with disability and industry.

Figure 1 shows the key elements of policy development with respect to encouraging the adoption of new technologies to improve the accessibility of public transport. The focus areas are interrelated, and each economy will need to decide which focus area requires the most attention.

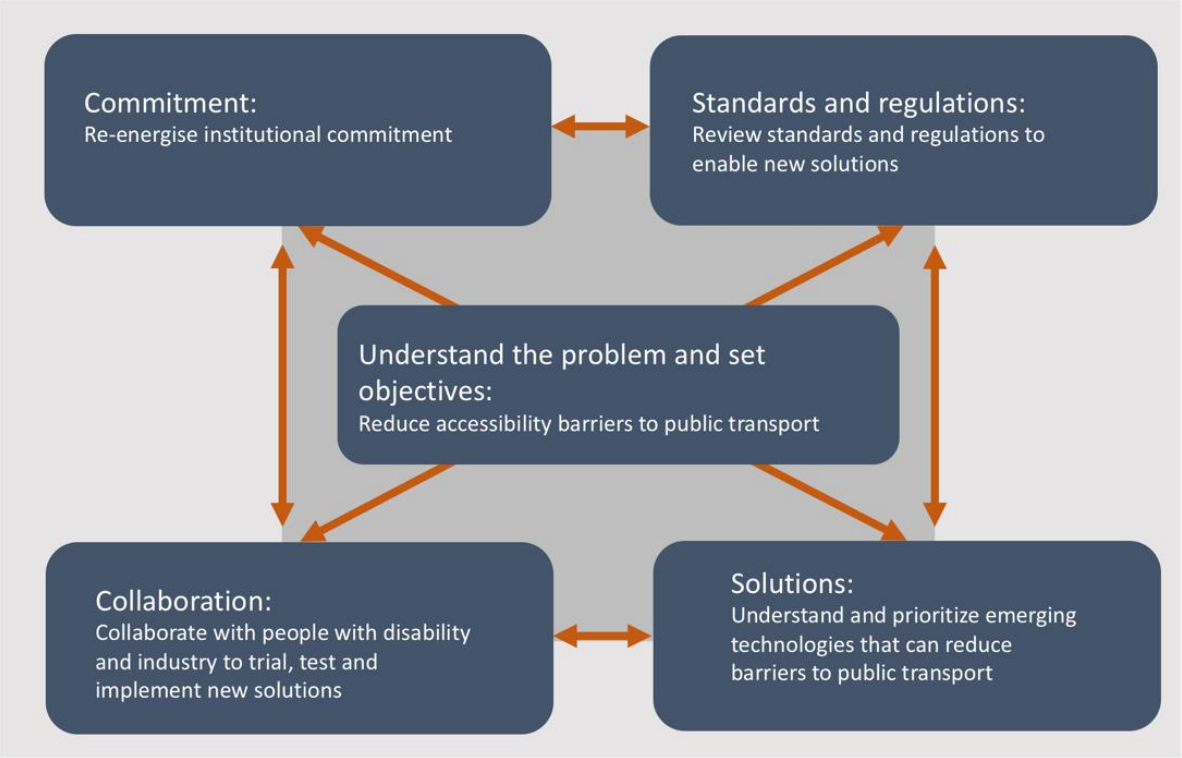


Figure 1: Policy development framework - focus areas

In this document, we provide guidance, best practice approaches and resources for each of the focus areas.

3.1 Understand the problem and set objectives

In this section, we suggest resources to help understand the fundamental accessibility issues, set specific and measurable objectives, and advocate for global benchmarking.

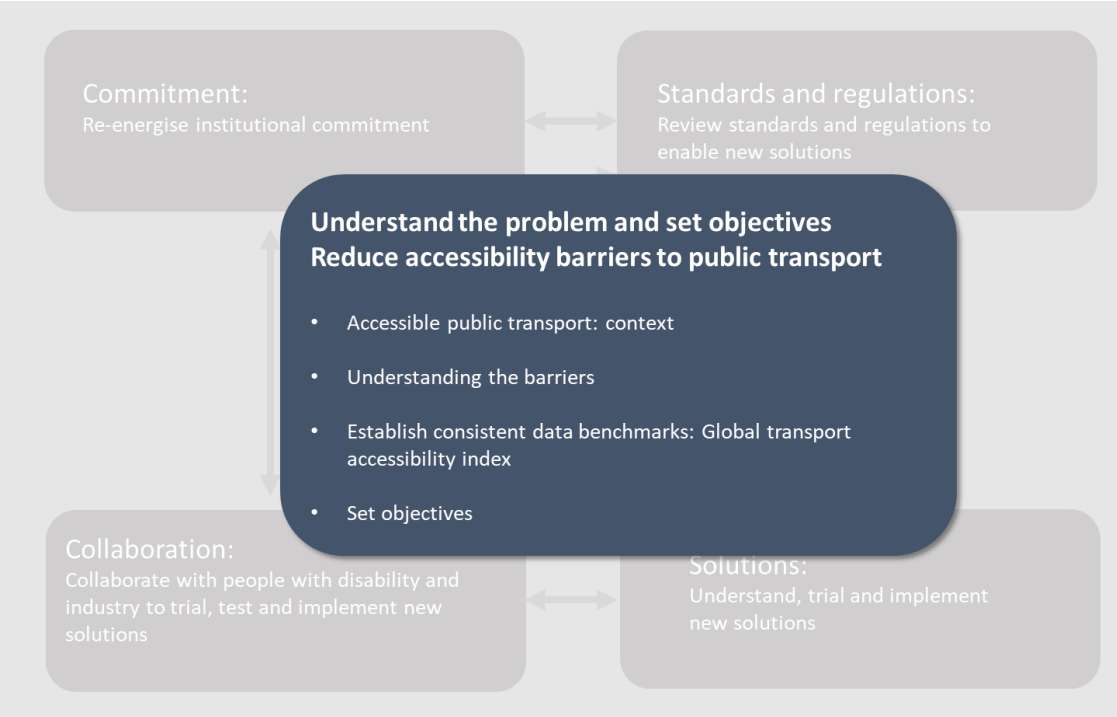


Figure 2: Understand the problem and set objectives

3.1.1 Accessible public transport: context

The accessibility of public transport for people with disability must be seen in relation to the overall accessibility of public transport for the general population. There is wide variation in the accessibility of public transport across member economies. If public transport is not accessible to the broader public, then inevitably it will not be accessible to people with disability. The Urban Mobility Index Report ranks the relative accessibility of cities public transit systems using the Public Transit Subindex (Olivia Wyman Forum, 2022).

3.1.2 Understanding the barriers

People with disability find inaccessible and unaffordable transportation 15 times more difficult than those without disability (WHO, 2023 a). In developing economies, data from selected economies in sub-Saharan Africa, Latin America and Asia show that 36% of people with disability consider transportation not to be accessible to them (WHO, 2023 a). Even in the wealthiest economies, such as the US, 25.5 million Americans aged 5 and older have self-reported travel-limiting disabilities. This is roughly 8.5% of the population. 3.6 million Americans with travel-limiting disabilities do not leave their homes because they are disabled or housebound (US Bureau of Transportation Statistics, 2022). In Australia, in 2018, there were 4.4 million Australians with disability, representing 17.7 percent of the population (Australian Bureau of Statistics, 2018).

Transportation planning has traditionally focused on mobility disability, including individuals who use mobility aids such as wheelchairs, walkers, and canes. But many other disabling conditions impede access to public transport, of which the vast majority are not visible. Such 'invisible disabilities' include sensory impairments, intellectual disabilities, autism, mental health issues, and many physical health issues. Aging is a major factor in disability and half of the 65+ age group have some form of disability (Fordham Institute, 2023). People may suffer from temporary or permanent disabilities, and many impairments result from car accidents, which can cause both physical and brain injuries. An illustrative, non-exhaustive overview for readers who are new to the field is provided in Table 1. The overview demonstrates that making a service truly inclusive requires an understanding of each disability type and its specific associated barriers to using public transport. For all cases, staff training is required to provide the right support.

Barrier	Description	Example Solutions
Hearing	Difficulty in hearing announcements or communication with staff or other passengers.	▪ Visual announcements: Display announcements on digital screens or boards at stations and on vehicles to supplement auditory announcements. ▪ Induction loop systems: Install hearing loop systems that transmit sound directly to hearing aids or cochlear implants. ▪ Text-based communication options: Provide information via text messages, mobile apps, or digital displays.
Seeing	Vision impairments that make it hard to read signs, maps, or recognise landmarks.	▪ High-contrast signage: Use high-contrast colours and large fonts for signage. ▪ Audible signals: Install audible signals at crossings and on vehicles. ▪ Tactile maps or braille information: Provide tactile maps or braille information for passengers.
Sensing	Difficulty in sensing environmental factors like temperature or pressure changes.	▪ Comfortable temperature control: Maintain comfortable temperature levels on vehicles and at stations. ▪ Seating with support: Provide seating with adequate support and cushioning. ▪ Minimise crowded areas: Implement crowd management strategies.
Moving (upper body and/or lower body)	Difficulty in physically navigating through stations, boarding, or disembarking vehicles.	▪ Ramps, elevators, and lifts: Install ramps and elevators at stations to facilitate wheelchair access. ▪ Priority seating: Designate seating areas near entrances for passengers with mobility challenges. ▪ Mobility aids: Offer wheelchairs or walkers for passengers who need assistance.
Speaking	Challenges in verbal communication, including expressing needs or asking for assistance.	▪ Alternative communication methods: Offer text messaging or chat services. ▪ Staff training: Train staff in basic sign language.

Barrier	Description	Example Solutions
Immunity	Vulnerability to illness or infection, which may make using public transport risky.	▪ Regular cleaning schedules: Implement frequent and thorough cleaning routines for vehicles and stations. ▪ Hand sanitising stations: Install hand sanitiser dispensers at stations and on vehicles. ▪ Proper ventilation: Ensure adequate ventilation systems in vehicles and stations.
Interacting socially	Challenges in engaging with others, such as difficulty in initiating conversations or interpreting social cues.	▪ Staff training: Train staff to recognise and assist passengers who may require additional support with social interactions. ▪ Designated assistance points: Establish designated areas where passengers can seek assistance.
Interacting socially	Difficulty in managing emotions, which may affect behaviour or decision-making while using public transport.	▪ Staff training: Train staff in de-escalation techniques. ▪ Quiet spaces: Designate quiet areas at stations or on vehicles. ▪ Alternative transport options: Provide alternative transport options or assistance.
Remembering and/or concentrating	Challenges in remembering routes, schedules, or focusing on tasks while traveling.	▪ User-friendly journey planners: Develop easy-to-use journey planning tools. ▪ Clear signage: Install clear and well-designed signage at stations and on vehicles. ▪ Assistance through mobile apps or staff: Offer real-time assistance and guidance.
Understanding Information	Difficulty in comprehending instructions, announcements, or other relevant information.	▪ Multilingual Information: Provide information in multiple languages. ▪ Simple language and clear visuals: Use simple and easily understandable language in announcements and signage. ▪ Personalised travel assistance: Offer personalised assistance services.

Table 1: Examples of common considerations for varying types of access barriers

In addition, there are people with temporary disabilities, people with a combination of disabilities and people with hidden disabilities. The Hidden Disabilities Sunflower, often worn as a lanyard, is a globally recognised symbol for non-visible disabilities, also known as hidden disabilities. It is a simple tool which allows people to share that they have a disability or condition which may not be immediately apparent and that they may need a helping hand and understanding, or require more time in shops, at work, on transport, or in public spaces (Hidden Disabilities website, 2024).

Solutions to many of these requirements have been codified into standards. These are minimum requirements and often trail behind technological and other design solutions. For instance, in Australia, the *Disability Standards for Accessible Public Transport, 2002* (the Transport Standards) contain standards to address various barriers. Standards are often supported by guidelines and *The Whole Journey Guide: A guide for thinking beyond compliance to create accessible public journeys* (DITRDCA, 2017), is a good example of general accessibility guidelines designed to complement legislated standards.

Whilst the Transport Standards provide the minimum requirements for accessibility, true inclusivity goes beyond this. For example, even when a train service may be accessible, the user may feel uncomfortable asking for a ramp and to be assisted from the platform onto the train. Stigma and negative social attitudes toward disability have a major impact on the willingness of people with disability to use public transport and their ability to experience the whole journey in a comfortable and safe manner.

> *Accessibility is about making sure people are technically able to use public transport, whereas inclusivity also looks at whether they feel confident enough to use it (UTIP, 2022).*

3.1.3 Establish consistent data benchmarks: Global transport accessibility index

Despite increasing awareness of the need for all people to have easy access to transportation, there is still a lack of metrics to measure accessibility in ways that are meaningful to users and can be used to inform transportation policies and set measurable objectives (Repetto, et al, 2022).

The World Bank has identified the chief challenge for disability inclusive transport as “the lack of reliable, disaggregated data on disability and disability-inclusive transport” (World Bank, 2015). Currently, existing data neither reflects the actual number of people with disability nor the inequalities they may experience. In the absence of this information, it is challenging to develop and advocate for inclusive policies and practices at domestic and local levels and to evaluate existing policies. The collection of standardised, disaggregated data is pivotal to addressing gaps in information and setting priorities.

One recent methodology was developed in Europe for the *Transport Innovation for Persons with disabilities needs Satisfaction* (TRIPS) project, a four-year EU-funded Horizon 2020 research project focusing on making public transport and shared services more accessible for people with disability and older people. One of the outcomes of the TRIPS project was a multi-dimensional mobility index (MDI), a new tool co-designed with people with disability to evaluate the accessibility of existing public transport. The MDI measures the gap that a user must overcome to have easy access to transportation systems (Repetto et al, 2022).

The implementation of the MDI is envisaged as a mobile application which enables users to send their feedback while travelling. This information is then sent to a web dashboard which automatically analyses and visualises the results of audits from users. The MDI collates detailed user feedback data so that it can be used for monitoring and planning access to urban mobility. The MDI is designed around six key parameters: travel time, comfort, affordability, safety, convenience, and autonomy as shown in Figure 3.

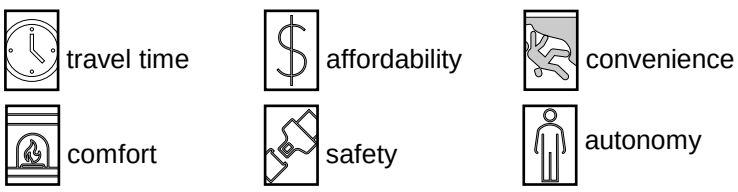


Figure 3: Six key metrics of the Multi-Dimensional Mobility Index (MDI)

If more economies applied the same metrics, the MDI could act as a valuable benchmark and an incentive to spur some form of international ‘competition’.

3.1.4 Set objectives

Setting objectives is a matter of bringing together organisations, visions and facts from all focus areas presented in this document to set measurable specific goals collaboratively.

The Accessible Public Transport in Victoria Action Plan 2020 – 2024 is an example of this. It is Australian state government plan which identifies opportunities to improve the whole-of-journey experience for people living with disability by collectively identifying gaps in accessibility and exploring other transport options, including new and emerging transport solutions. All priorities and actions are seeking to ensure that measurable outcomes are achieved resulting in beneficial changes in the lives of people with disability. (Victorian Government, 2023).

The UK Government also provides an example of a defining goal for accessibility in public transport:

> *Our vision is for disabled people to have the same access to transport as everyone else. They will travel confidently, easily and without extra cost. By 2030, we envisage equal access for disabled people using the transport system, with assistance if physical infrastructure remains a barrier. (UITP, 2024)*

3.2 Commitment: Re-energise institutional commitment

Major change requires institutional commitment. The foundations for change have existed since 2008 when the *United Nations Convention on the Rights of Persons with Disability* (2006) (CRPD) came into force. As of July 2023, the Convention has now been ratified by 185 of the 193 UN Member States (OHCHR, 2023) and provides a solid basis for action.

This section highlights some key requirements of the CRPD in ensuring that accessible public transport is a commitment, not just a gesture. This includes the adoption of universal design (UD), the principles of which are briefly outlined as follows. Lastly, section 3.2 offers various ways to assess the cost versus the benefits of making transportation more accessible.

UD provides an excellent foundation to develop solutions for transport accessibility to the whole community; but UD principles are not specifically targeted to address the differing variety of requirements for those with disabilities. For example, sheltered bus stops, real-time information and stepless access to trains and buses improve accessibility to transportation for everyone. But in other instances, specific technological interventions are required, such as navigation aids for the visually impaired or automated wheelchairs. There is a difference between the concept of creating specific and tailored solutions for individuals with disability, and UD, which is intended to make transportation as accessible as possible for as many people as possible, regardless of whether they have an impairment. Both approaches are complementary, but they can also operate as alternatives.

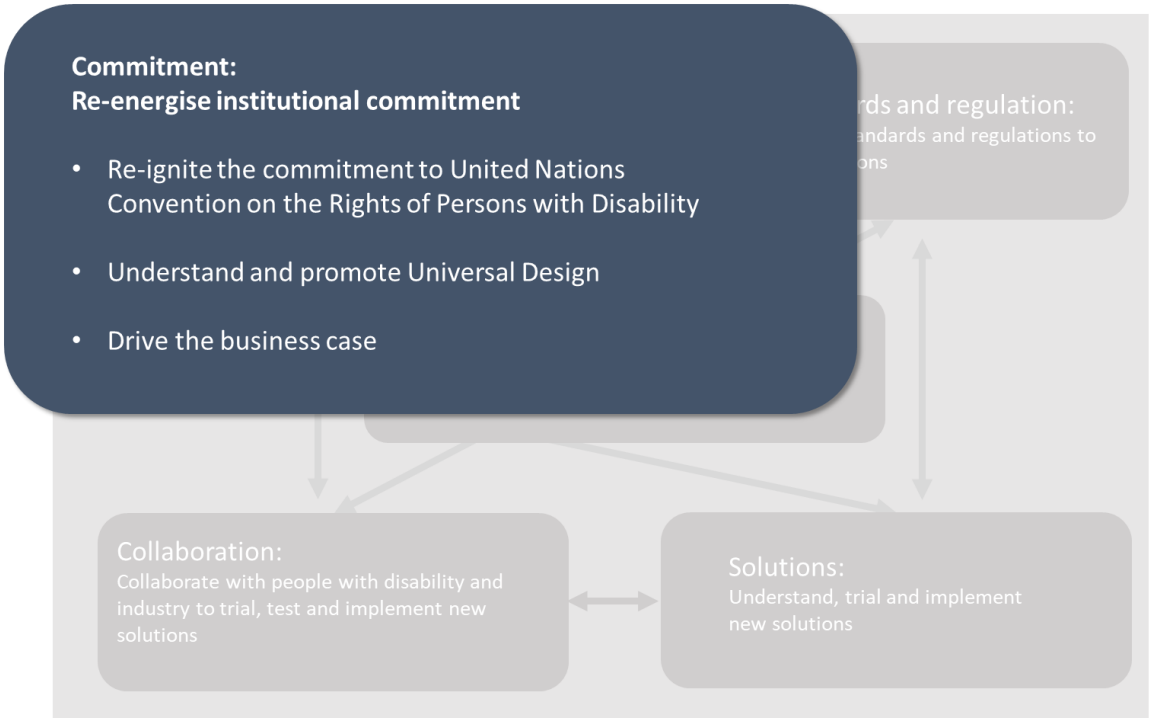


Figure 4: Re-energise institutional commitment

3.2.1 Re-ignite the commitment to the UNCRPD

Put simply, access is about getting where you want to go as easily as possible (Repetto et al, 2022). The CRPD defines accessibility as the degree to which people with disability can have:

> *…access on an equal basis with others, to the physical environment, to transportation, to information and communications, including information and communications technologies and systems, and to other facilities and services open or provided to the public, both in urban and in rural areas. (CRPD, Article 9).*

The CRPD has had a major impact on the way disability is perceived across the world. Ratifying the Convention does not mean that all State Parties automatically include the provisions of the CRPD in domestic law, but it does provide an international standard from which to formulate laws and policies, and from which to interpret disability discrimination legislation (McCallum, 2020). Equal access to the physical environment, to transportation and to other facilities and services is viewed in the Convention as a pre-requisite for people with disability to enjoy their human right to live independently and participate in all aspects of life (AHRC, 2023). In relation to transportation, technology and disability, State Parties are obliged by the CRPD to make commitments relating to improving access to transportation through Articles 4, 9 and 31.

Article	Article highlight
Article 4: General Obligations	▪ Undertake research and development of universally designed goods, services, equipment, and facilities. ▪ Undertake research and development of new technologies, including assistive technologies. ▪ Provide information to the disabled on the available assistive technologies.
Article 9: Accessibility to Transportation	▪ This Article requires all State Parties to take appropriate measures to ensure equal access of people with disability to transportation, including (inter alia): ○ Identify and eliminate obstacles and barriers to accessibility in buildings, roads, transport, and information. ○ Develop and monitor minimum standards and guidelines and ensure private entities do the same. ○ Promote the design, implementation, and distribution of accessible information and communication technologies, which should be accessible at a minimum cost. ○ All newly designed objects and products should be fully accessible.
Article 31: Statistics and Data Collection	▪ Emphasises the obligation to collect data and information as a basis for formulating policies and to share that data where appropriate.

Table 2: CRPD articles regarding accessible transportation

In short, accessibility is well-established by the CRPD as an obligation for State Parties to ensure equality and non-discrimination. This commitment is further reinforced by the *2030 Agenda for Sustainable Development*, and its 17 sustainable development goals (SDGs) that pledge to leave no economy[1] and no one behind. The CRPD is a tangible convention that can make a real impact on the lives of people with disability, if actioned appropriately.

3.2.2 Understand and promote universal design

The CRPD defines UD as "*the design of products, environments, programs and services to be usable by all people to the greatest extent possible*." This includes assistive devices (Article 2, Definitions). The CRPD also specifies that disability should be considered in all development programming, rather than as a stand-alone thematic issue (AusAID, 2013). The Centre for Universal Design Australia (CUDA) states that UD is a design thinking process intended to create an inclusive society, which can be applied to everything we design.

The 7 principles of UD originated in 1997, and over the years, the interpretation of these principles has varied between different design disciplines. Some of the criticisms of the original principles are that they were most suited to product design and were not readily applicable to other design fields because they lack certain details such as benchmarking metrics, clear goals, and clarity of purpose. The language in which they are expressed can be difficult to understand (IDEA, 2024). Nevertheless, they remain in use to this day, although modifications and elaborations of their application have continued to evolve.

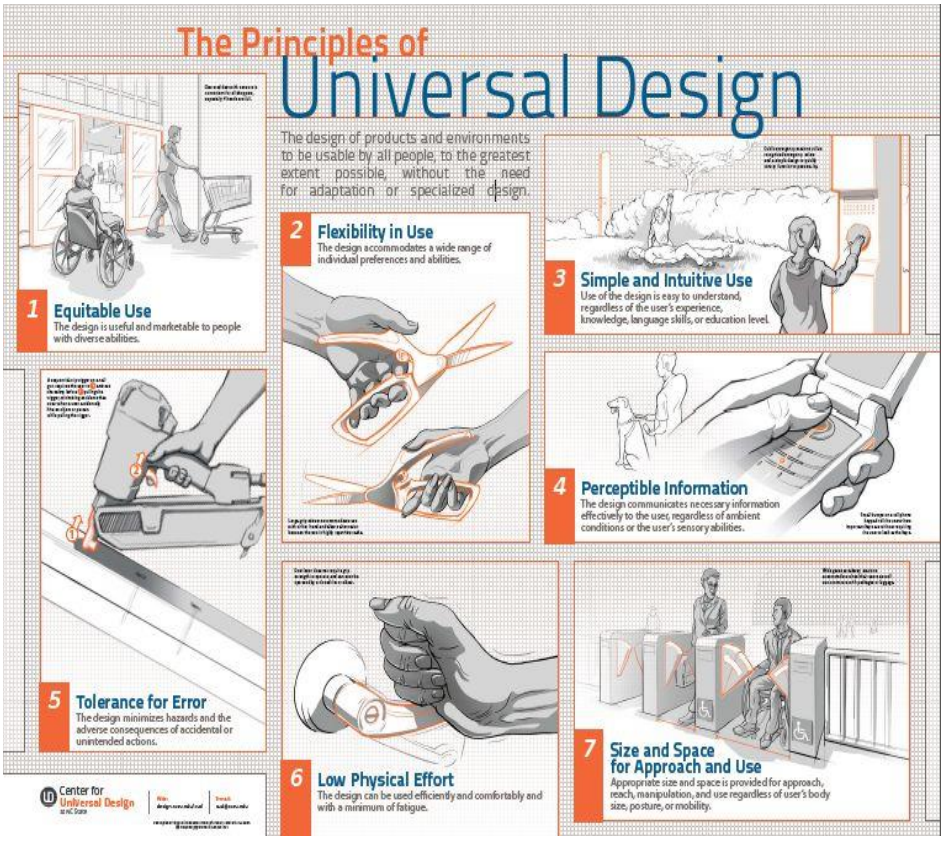
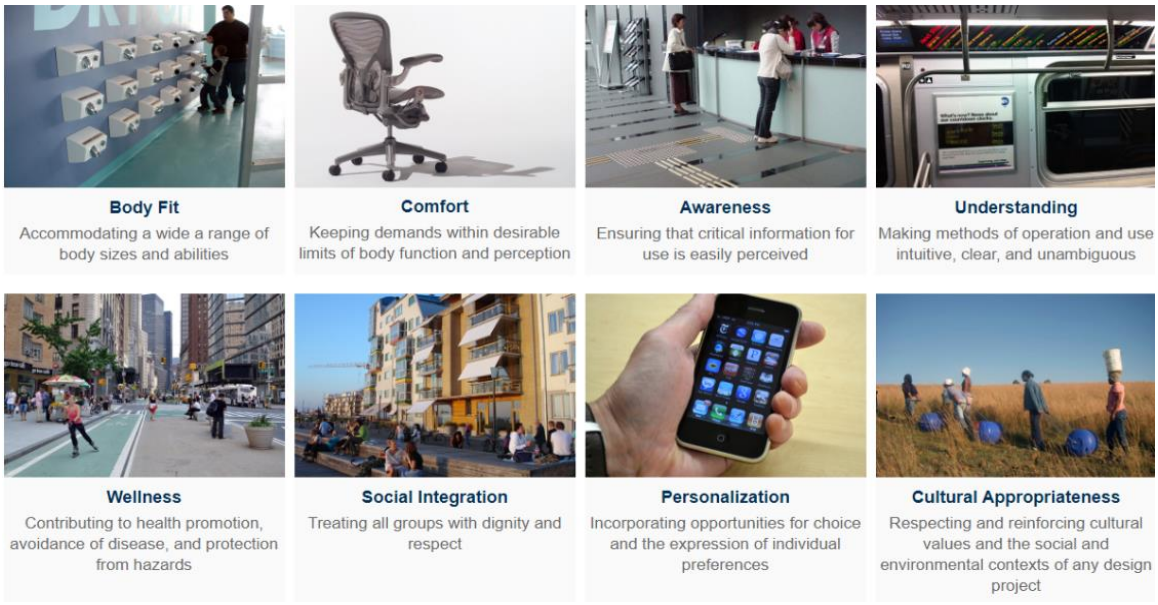


Figure 5: The key elements of Universal Design (copyright, The North Carolina State University Center for Universal Design)

[1] The term referenced in this report does not imply the political status of any APEC economy.

In 2012, Steinfeld and Maisel developed the 8 Goals of Universal Design to ensure that UD goals can be measured and applied across a wide range of design domains (IDEA, 2024). Using the 8 Goals of Universal Design in conjunction with the 7 principles gives a more practical and adaptable application of the UD concept. The Goals offer a clearer interpretation of the principles and provide a framework that is applicable to both research and practical applications. More recently, UD aims to include users in the design process and co-design methods (CUDA, 2024).

Figure 6: The 8 Goals of Universal Design (University at Buffalo, Center for Inclusive Design and Environmental Access)



Inclusive transport that applies UD principles is an important part of any comprehensive strategy to ensure the inclusion of people with disability. Wherever possible, accessibility should be factored into projects right from the start; and for older systems which cannot be retrofitted, creative alternatives need to be found (World Bank, 2015). Accessibility should be a non-negotiable condition of funding for new developments and refurbishments.

Tips for promoting UD include: (adapted from AusAID, 2013)

- Ensure the provision of UD principles in legislation, building standards and codes. Advocate for UD principles to be reflected in local laws and policies.
- Include costs for inclusive design as part of the overall construction costs and not as an add on.
- Establish early collaboration between government representatives, infrastructure designers and Disabled Peoples' Organisations (DPOs).
- Consult with DPOs throughout the project cycle, and after the project is complete, to assess the effectiveness of the design and the lessons learned.
- Include people with disability on general planning committees to ensure a better understanding of the barriers faced by people with disability.
- Capture lessons learned and ensure that these are incorporated into future projects. Publicise good practice.

Note that in some cases, UD is criticised for setting impossible goals: "*one solution can never fit all."* This is true; each type of disability may need a dedicated solution. We see UD as an ambition and approach to achieve universal access to public transport for all. Where one solution does not fit all, complementary solutions are required to ensure universal

access. The term ‘user centric design’ is a frequently used alternative, and is probably more apt in that it doesn’t assume that that there is one solution for all, but the term itself lacks the ambition to achieve full inclusivity.

3.2.3 Drive the business case (cost vs benefits)

Access to transport is a key enabler of social inclusion, economic participation, obtaining healthcare and maintaining independence for people with disability. Therefore, accessibility should be promoted as a collective good. Quantifying and capturing the added socio-economic value is beneficial, not only for those with disability, but for the population at large. Making public transport more accessible is a win-win for everyone. It is good for people with disability it is good for our communities, and it is good for the economy (NDS, 2022).

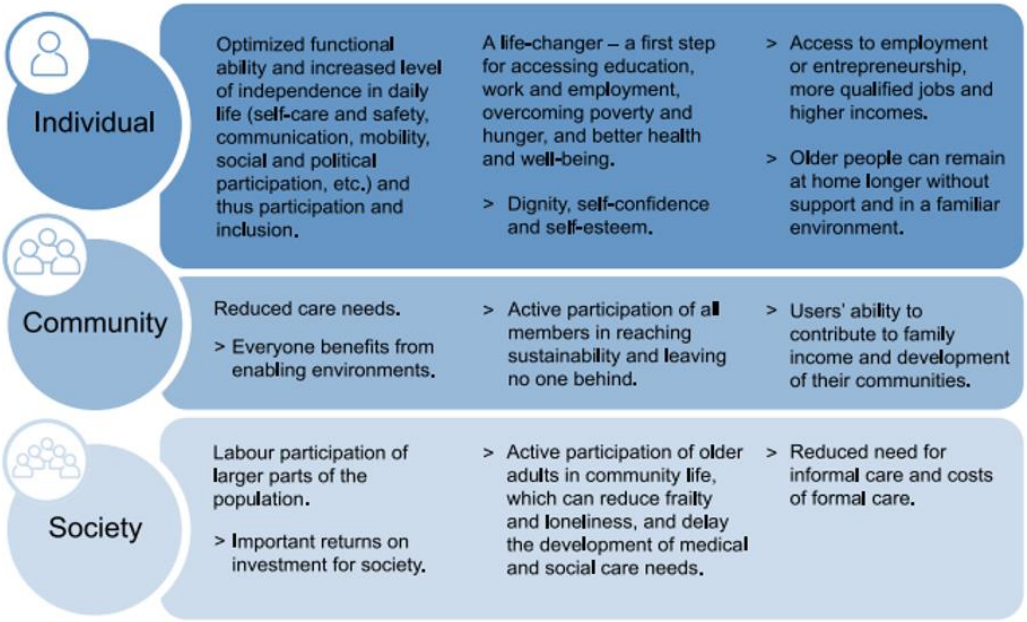


Figure 7: Benefits of assistive technology for the individual, community, and society (WHO, 2022)

The benefits which can arise from improving access for people with disability to transportation include:

- Improving access to employment, resulting in a reduction in poverty.
- Increasing independence, leading to a greater involvement in education, shopping, travel, health services, and community participation.
- Greater quality of life and health benefits resulting from less isolation, more autonomy and increased ease of mobility.
- Economic benefits to the general economy as people who can access public transport are more likely to work and travel.
- Environmental benefits because people who use public transport are less likely to drive cars, which contributes to air pollution and traffic congestion. (NDS, 2022)

The World Bank has studied the cost and marginal cost of making elements accessible. In terms of overall cost, they found that 60 percent of the analysed accessibility features are cheap or very cheap; 35 percent are moderately expensive; and only five percent are considered expensive. In terms of marginal cost, 70 percent of the analysed accessibility features are cheap or very cheap; 27 percent are moderately expensive; and only three

percent are expensive. A Nordic Welfare Centre research project published in 2024, analysing 45 studies and seven literature reviews on the costs and benefits of UD measures to increase accessibility for people with disability, found that improvements in accessibility provide benefits not only for the disabled but also for secondary groups. The report recommends that it is just as important to study what prevents people from travelling as to study the benefits of accessibility for those who do (Nordic Welfare Centre, 2024).

The UN Department of Economic and Social Affairs (UNDESA) estimates that the costs of including UD principles from the commencement of planning are low:

> *…urban infrastructure, facilities, and services, if designed and built following accessibility or inclusive 'Universal Design' principles from the initial stages of planning and design, bear almost no or only 1 per cent additional cost (UNDESA, 2016).*

On the other hand, failure to include people with disability could result in costs such as those arising from exclusion from the labour force, leading to "substantial losses, for example of up to around 7 percent of GDP" (UNDESA, 2016). A recent international study from the Centre for International Economics, *Economic cost of violence, abuse, neglect, and exploitation of people with disability* identifies transport inaccessibility as resulting in losses ... "at an estimated economic cost of $200 million per year" (AHRC, 2023 a). Given the current global insufficiency of data on disability access, this is likely to be an underestimate.

Return on Disability (ROD), a Canadian-based company cited in the UN estimates of potential revenue for disability-inclusive infrastructure, provides advice to the private sector on disability inclusion. ROD estimates that the number of people with disability globally- 1.85 billion - constitutes "an emerging market the size of China" with a disposable income of approximately USD 1.9 trillion annually. The expanding number of older people, whose needs align closely with those of the disabled, is the "wealthiest demographic in history".

Currently, even in prosperous economies, people with disability are usually financially disadvantaged. The costs associated with purchasing assistive devices can pose an insurmountable challenge to those who are in most need of them. As a result, many individuals with disabilities continue to face barriers in using public transport, exacerbating their social exclusion and limiting their ability to participate fully in society. Addressing the affordability of assistive technology should be a policy goal for fostering inclusivity and ensuring equal access to transportation for all members of the community.

3.3. Standards and regulations

New technologies often require new regulations to support innovation while also protecting consumers from harm. *Forbes* magazine published an article in 2022 entitled *13 Tech Areas, Functions and Laws Facing New or Potential Government Oversight* (in the United States). Areas that were identified as requiring new regulations include artificial intelligence and machine learning, data mobility, caller ID, cybersecurity risk management, user data and content oversight, digital payments and cryptocurrency, data transfer between economies, online retail, cybersecurity breach reporting, medical device cybersecurity, digital invoicing, general data protection regulation and consumer privacy, and state-level privacy acts (Forbes, 2022). We list all these because all or any of these areas may need to be addressed as they are a part of emerging technologies in transport.

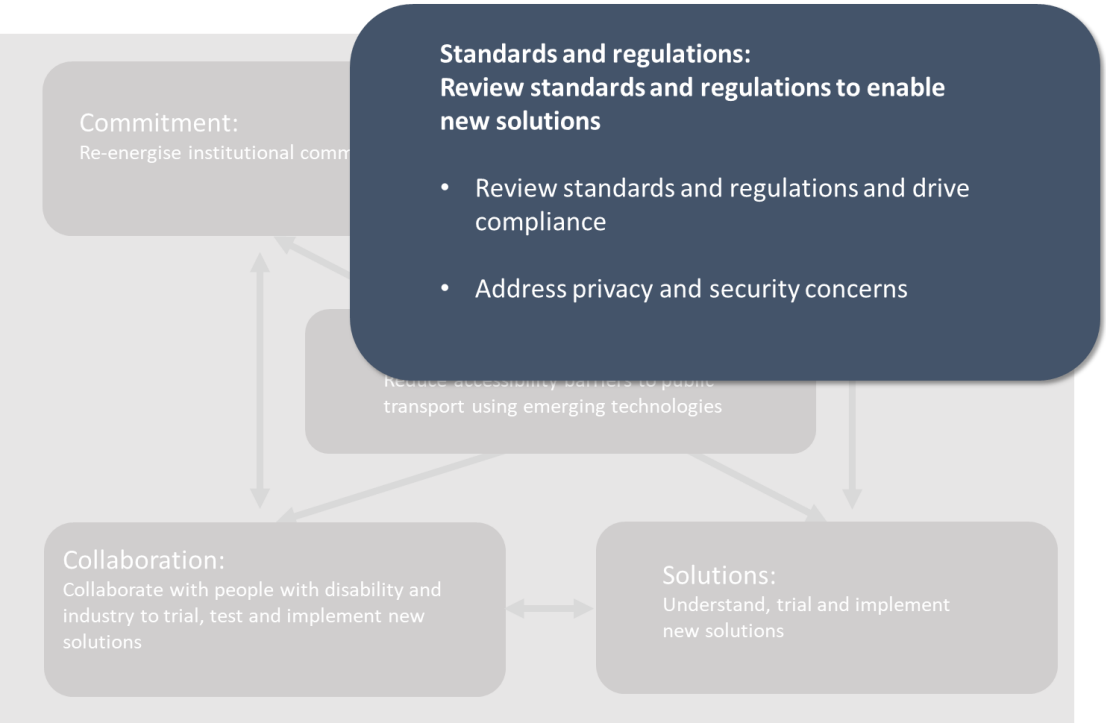


Figure 8. Standards and regulations: Review standards and regulations to enable new solutions

3.3.1 Review standards and regulations and drive compliance

To drive change, undertaking an initial policy assessment on the existence and quality of local policies, strategies, legislation, and guidelines can help to identify gaps in current systems and laws. It also provides the opportunity to address the fragmentation of roles and responsibilities for disability access, for example, where there are different stakeholders responsible for roads, infrastructure, trains and buses, disability, and social affairs (World Bank, 2022 c).

By way of example, Australia implements the CRPD through legislation, policy, and programs. Among these are the *Disability Discrimination Act 1992*, the *National Disability Insurance Scheme Act 2013 (NDIS Act)*, Australia's *Disability Strategy 2021-2031,* and the *Disability Standards for Accessible Public Transport 2002* (the Transport Standards). The Transport Standards establish minimum accessibility requirements to be met by providers

and operators of public transport conveyances, infrastructure, and premises. They are reviewed every five years.

Standardisation has a key role in defining the minimum requirements that need to be met. To date, there is no specific or comprehensive international standard for accessible transportation.

Enforcement of the standards is another matter and representative bodies often call for stronger tools to drive compliance. Improving standards often relies on people with disability making complaints about breaches of accessibility. This places an unfair burden on people with disability to hold transport operators responsible for non-compliance and to be sufficiently well informed on technical requirements to be able to identify where a breach has occurred. Therefore, legislative provisions for transport accessibility need to harmonise with the goals of accessible transport standards, and enforcement powers need to be assigned to an appropriate body. All existing relevant legislation should be reviewed to ensure that breaches of compliance can be enforced (AHRC, 2023 a).

The 2023 review by the Australian Human Rights Commission (AHRC) of the Transport Standards made numerous suggestions for monitoring compliance with disability access standards, including the establishment of a domestic framework for mandatory compliance reporting and the regular collection of data which should be made publicly available. The AHRC recommended that the monitoring and compliance framework be co-designed in consultation with the disability community and that accessible transport standards should be based upon the principles of universal design “to ensure that minimum standards maximise accessibility, use and benefit” (AHRC, 2023 a).

3.3.2 Address privacy and security concerns

Central issues in the emerging technology context are privacy and security. As data collection, management, and use are key components in high-technology scenarios, sensitive data handling and cybersecurity are going to become priorities for government organisations and private companies.

Data collected from mobile health apps can contain profoundly sensitive personal information such as sexual orientation, gender identity, mental health, genetic information, and lifestyle choices. Even seemingly innocuous data can be utilised to infer personal information. Protection of this information is critical as many individuals may face discrimination if it were to be publicly revealed (Borges et al, 2023).

A 2023 report for European Digital Rights (EDRi), an association of civil and human rights organisations across Europe, by George Washington University examined the limitations of the current privacy legislation in Europe and proposed several policy recommendations to better protect individuals’ data and privacy:

- Require health data collection agreements to have user–centric transparency with ‘opt–in’ consent and appropriate enforcement by regulators.
- Explicitly protect data inferences.
- Require health apps and wearable devices to be certified by a recognised third–party organisation.
- Strengthen collective data rights through transparency and standardisation efforts.

Too much data protection, however, can also become an impediment, as data and inferences from data patterns are required to make improvements to public transport. For instance, to measure how many people with guide dogs take certain buses or trains, people with disability would have to disclose this, even though they may feel reluctant to do so, as discrimination against guide dogs is still common. The key will lie in the consent that is given and the current practice of applying one blanket consent form needs to be replaced by a consent process that is more situation specific or time limited.

3.4 Technology opportunities to improve accessibility

In most economies, the major barrier to people with disability accessing public transport is the existing built environment. According to the EU-funded TRIPS study (*Transport Innovation for People with disabilities needs Satisfaction*), completed in 2023, the most challenging aspects of the journey for people with a disability are:

- Getting on and off transport.
- Difficulties reaching an access point, such as a bus stop.
- First and last-mile issues around accessibility to urban infrastructure, including lack of pedestrian walkways or dangerous crossings.
- Entering and using station facilities.
- Delays in travel due to an inability to board a mode of transport because of gaps at station platforms or a lack of space for wheelchairs.
- Comfort while traveling.
- Access to travel information.

Technology on its own cannot help with issues that are more appropriately addressed by making physical changes to the infrastructure, such as a lack of ramps for people in wheelchairs, a lack of tactile guidance for blind people, long distances between trains and connecting buses, inaccessible toilets, unsafe vehicle exits, insufficient lighting, and so forth. There will always be a need to understand gaps in accessibility and provide alternatives for those for whom technology will not be a solution.

We are mindful that to date, technology is often more promising in its conception than in the delivery. Too many innovations have been launched prematurely, ultimately resulting in disappointment once they are in operation. The rapid introduction of new technologies can also lead to a chaotic marketplace, where devices are both incompatible with infrastructure and with each other. Hence, we advocate for early involvement by governments to provide co-ordination to ensure the compatibility of technology, as well as to enforce minimum performance standards.

Also, technology developments are not always accessible to everyone. A digital divide is emerging. As many as 3.7 billion people across the world remain unconnected (IEEE, 2024). The article states that “a lack of infrastructure is a major cause of the digital divide, but it is also a result of other factors such as poor digital literacy education, inequitable access to technology, and a lack of support from governing institutions.” When digital access and literacy lags in sufficient numbers, the entire economy suffers significant economic loss. One model for improving access to new technologies is the EU report released in 2020 called the *Digital Decade,* which outlines the EU’s framework over the next decade for ensuring no one is left behind in the current technological revolution (IEEE, 2024).

However, taking the ‘false promises’ as well as the digital divide into consideration, there are many areas in which technology can help, especially in the technological advancement of transport. While significant achievements have been made in terms of improving the physical accessibility of transport, digital accessibility and inclusion have not been fully addressed (UTIP, 2023). There is a recognised need for better digital services to aid disabled users' mobility and overall quality of life. There is also a need for better digital education and tools to enhance social inclusion. To rise to the challenge of universal accessibility, cities can

benefit from innovative technologies that promote a barrier-free and inclusive society.

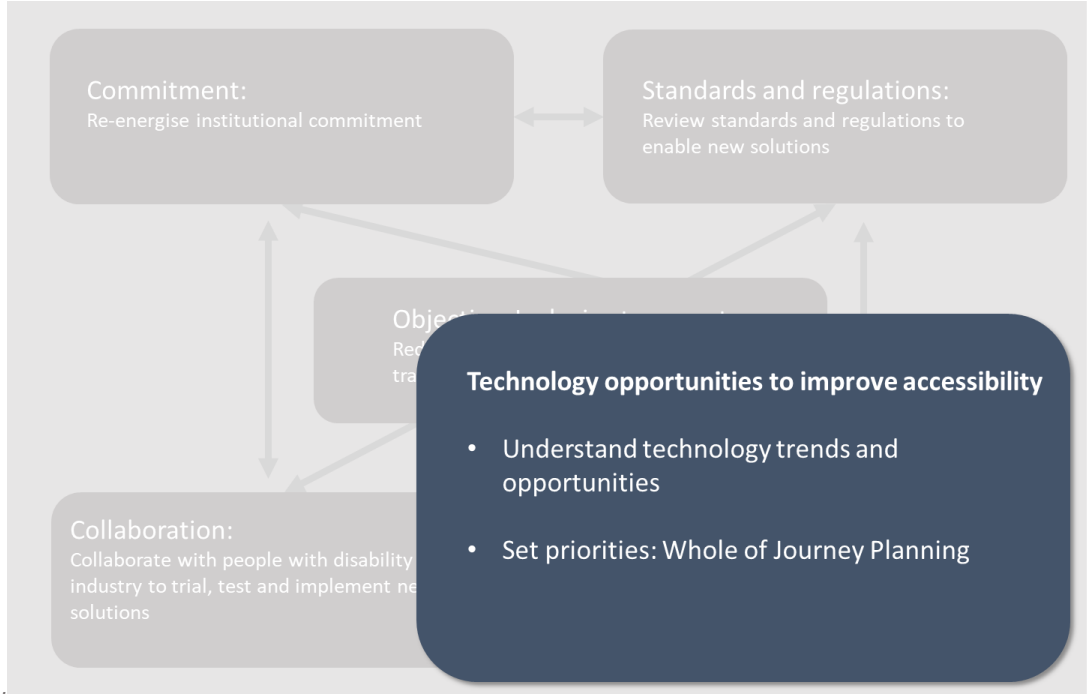


Figure 9: Solutions - Technology opportunities to improve accessibility

3.4.1 Understand technology trends and opportunities

New technologies are changing the future of transportation, enabling future visions for mobility that are different from what they were just a few decades ago.
Transportation is becoming less about moving more vehicles faster. Instead, the future of transportation will shift toward less reliance on personal motorised transport, with an emphasis on low-polluting transport solutions. There will be an increased focus on social equity and inclusiveness; on harnessing technology; on encouraging public-private partnerships; and on promoting community engagement and participation (UN smart mobility principles).

Some near-term examples of the future of smart mobility include Cooperative Intelligent Transport Systems (C-ITS), which refer to transport systems where two or more sub-systems can communicate. This may include vehicles that can communicate with other vehicles and/or infrastructure components (Aarhaug, 2023). New modes of transportation are being developed and tested such as Elon Musk's 'Boring' tunnels, flying taxis, driverless drones for transporting goods, driverless vehicles, and ultra high-speed rail to mention a few. In the next section, we provide a high-level overview of the potential of innovative technologies that can provide better accessibility for people with disability to public transport.

AREAS	KEY DRIVERS	INSIGHTS
Digital and technology development	Robotics, autonomous vehicles, drones	Autonomous vehicles, also called driverless or self-driving cars, can navigate and overcome obstacles without a driver. Massive adoption of autonomous vehicles could transform all aspects of live because people could enjoy additional free time while using them. Drones offer a variety of services ranging from environmental monitoring to traffic management.
	Rise of AI	AI has potential to change the smart mobility sector through various capabilities such as computer vision, voice recognition, and prediction. Those capabilities play fundamental technical roles in smart mobility solutions such as autonomous vehicles and drones. In the meantime, AI can be used for surveillance systems and traffic management.
	Smart phones and mobility platforms	Smart phone-enabled apps have provided options for mobility and tracking of travel information. Mobility solutions such as on-demand transport and micro-mobility options such as bicycle and electric scooter rentals are often available via smart phone apps.
	Financial technology	Payment for mobility is becoming more digitised and streamlined. Financial technology, such as mobile wallets and digital payment solutions, offers convenience and transparency.
	Mobility as a service	Mobility as a service is the integration of multimodal transport services into a single mobility service accessible on demand. It offers commuters added value through use of a single application to provide access to mobility services, with one payment channel.
	Connectivity, Internet of things, transport data-gathering sensors	Connectivity is a fundamental factor for smart mobility, connecting vehicles, roads, and traffic lights, among other things, with Internet access. Communication between vehicles and road infrastructure is a critical enabler for autonomous vehicles. Connected sensors may also be employed to collect data to improve transport (e.g., preventive maintenance, intelligent conservation of roads).

Table 3: Technologies are developing rapidly, and hold promise to fundamentally change the concept of mobility (The World Bank, 2023)

The changing mobility landscape provides fertile ground for assistive technologies to make a difference. Assistive products encompass a broad variety of products that cater to a large variety of disabilities. Increasingly, these products are produced with electronic components which make them smart, connected, and often automated.

We reviewed numerous technologies that can help improve the accessibility of public transport for people with disability and grouped solutions into six categories (see figure 10 on the next page). For each category, we provide examples.

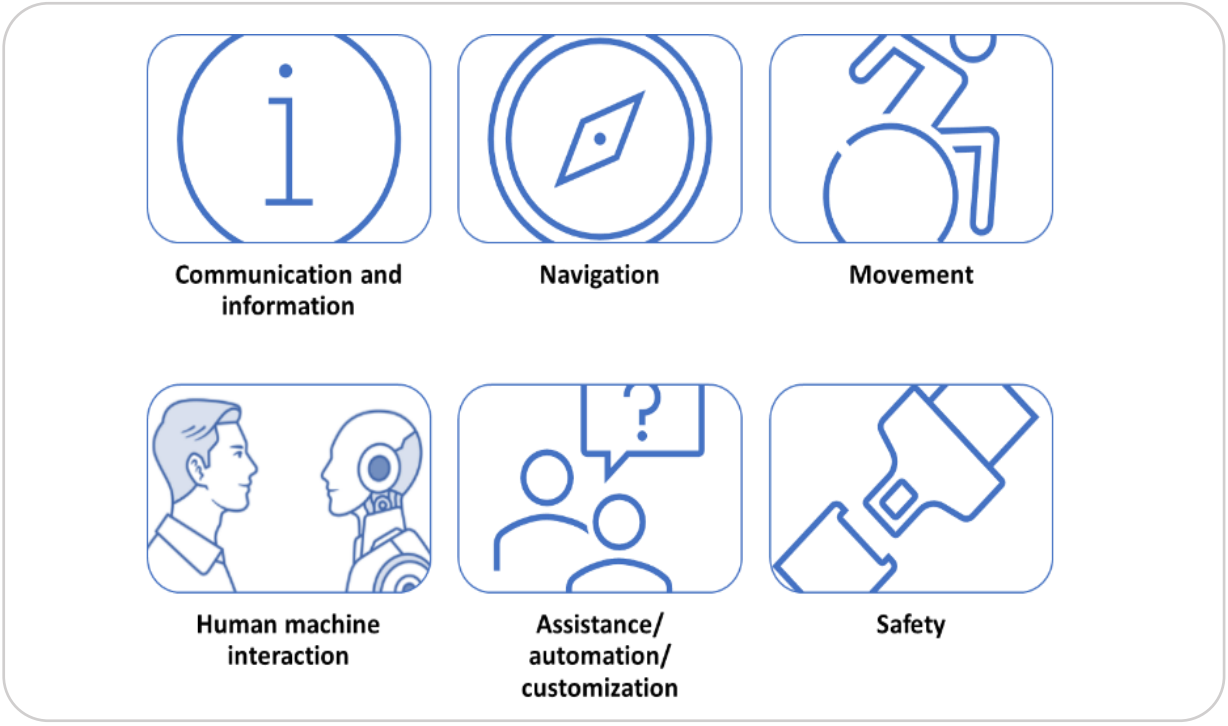


Figure 10: Six key accessibility innovation territories (Source - La Trobe University)

Communication and information

In emergencies, people with disability are often the last to find out what is going on. Even when a train changes its departure platform, people with disability are not informed. Today, emerging technologies allow people with disability to receive and send information.

Examples[2] include:

- Phones are becoming more sophisticated assistive tech tools. Apple has an app called *'Apple listen'* which can amplify sounds to a Bluetooth headset or hearing aids.
- The *WeWALK* smart cane, which uses an ultrasonic sensor to detect obstacles above waist level and deliver haptic feedback to the user.

Figure 11: WeWALK Smart Cane is a connected device to provide guidance

- Smart glasses are re-emerging, useful for people with vision impairment. *Xander Glasses,* for instance, offer a simple, hands-free way for people with severe hearing loss to understand speech. The glasses have tiny microphones that listen and provide scripts in real time, empowering people with hearing challenges in daily conversations. They are also designed to overlay digital content-like notifications, maps, and more onto the user's view of the real world, providing an interactive, immersive experience.
- Communication with people who are both deaf and blind, one of the biggest challenges, is possible with devices such as *Smart Beetle*. Smart Beetle is a 14-cell refreshable Braille display that is connected to Bluetooth and fits in a pocket.

[2] For a report with more examples, please contact the authors.

Navigation

Getting to the pick-up point (e.g., the bus-stop, train platform) is often only half of the accessibility challenge. Technologies are advancing that are much more accurate than GPS and can help people navigate in unfamiliar environments.

Examples include:

- *GoodMaps* provides an AI-driven indoor mapping platform, offering greater accuracy and accessibility without the burden of hardware installation. This Simultaneous Location and Mapping (SLAM) technology deploys entrance-to-destination wayfinding quickly so passengers, including those with disability, can find their way independently and with increased safety.
- *Click-and-Go* uses beacons to make wayfinding signs active, becoming audible landmarks with the ability to send information to phones.
- *Navilens*, a phone technology, recognises sophisticated augmented QR codes and provides information, such as the bus number if the code is on a bus. This facilitates access to transport for people with vision impairment.

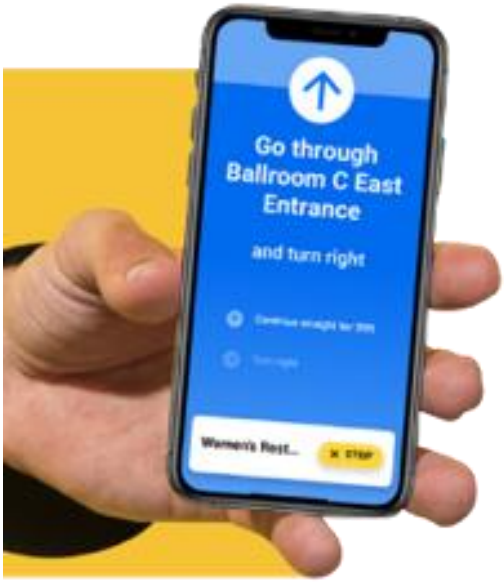


Figure 12: GoodMaps

Movement

Making the connection between different modes of transportation is often a challenge. Emerging automated technologies can help people overcome barriers they were not able to overcome without assistance.

Examples include:

- *Automated wheelchairs* in Tokyo airport automatically take passengers to their departure gate (and drive themselves back to the starting point).
- *New automated modes of transport* are being trialled all over the world, including electric vertical take-off and landing (EVTOL) aircraft or flying taxis, which can play an important role in assisting people with disability in the future.


Figure 13: Automated wheelchair, Tokyo airport

- Traditional *wheelchairs* themselves are becoming more sophisticated. They can ‘climb stairs’, are powered but still light, and they are increasingly connected to the internet to support navigation and other services. Currently, the price tag is a hurdle, but these technologies are rapidly becoming more affordable.

Human machine interaction

What is a simple button for many people can pose a serious challenge for people with disability, for instance, if the button isn’t clearly visible, or too high, or not positioned in same location consistently. Touch screens are becoming more pervasive, but also pose a challenge for many people with disability. Today, with emerging technologies, there are more

ways for people with disability to communicate with systems such as ticketing machines, but there are also ways to interact with systems that were not previously available, such as the traffic light system.

Examples include:

- *Neatebox* allows people with disability to request a little more time with a green light to safely cross the road, increasing their level of safety.
- Globally, *ticketing systems* are becoming increasingly sophisticated, reducing the friction of having to buy a ticket or know where exactly to tap off and on. Trials are underway to test the 'Be in, Be out' ticketing system that allows access to public transport and automatically issues a ticket using the wireless recognition of a token or face recognition.

Figure 14: Neatebox connects pedestrians to traffic lights.

Safety

Safety for people with disability is an important consideration. A variety of safety improvements have been developed.

Examples include:

- For *wheelchair users*, wheelchair security on buses and trains is an issue, in part due the variety of wheelchairs and lack of a universal method to secure them. Today there are solutions that can secure wheelchairs of all shapes and sizes using AI and scanning technologies, without the need for assistance. Other hazards such as gaps between train platforms are increasingly bridged by automatic ramps that roll out without the need for human assistance.

Figure 16: Q'straint Quantum Wheelchair Self-Securement Station

- *Smart lights* that light up when people are detected can improve the feeling of safety without increasing the cost for a wide range of people with disability.
- *AI powered cameras* can detect potential danger and violence, enabling safety officers to intervene quickly.
- For people with a vision impairment, smart devices are available, such as the WeWALK smart cane, which detects hazards which traditional canes cannot detect.
- *Biped* is a smart harness that uses self-driving technology to guide *visually impaired* people with 3D sounds, helping them to avoid obstacles and navigate safely.

Assistance

Knowing how to seek assistance in crowded or unfamiliar environments is not only important for people with disability but also for tourists and the elderly.

Examples include:

- Emerging technologies such as *audible signage*, translation screens, and timely notifications of delays can help users go about their journey with minimal anxiety or frustration. *Smart glasses* and phones can facilitate assistance over a distance by allowing a remote human to see what is in front of the person.
- When people with disability require human assistance, and someone from a distance can help, *Be My Eyes* lets people from a remote location look through the camera of your phone. This app increasingly uses AI instead of an actual person looking through the viewfinder remotely. AI is learning to recognise situations and provide the correct information on request in real time.

Figure 15: A screen that transcribes and translates languages (Tokyo)

3.4.2 Set priorities: Whole-of-journey planning

The aim of whole-of-journey planning is to change the focus of transport planning from compliance with regulations and standards, to one of aiming for a travel experience which is accessible, comfortable, seamless, efficient, and cost effective. The whole-of-journey approach requires cooperation and discussion between those who deliver the transport system, those who service it, and its users. Everybody needs to work together to identify issues, solutions, and opportunities (DITRDCA, 2017).

Whole-of-journey thinking includes the pre-journey planning, the journey's start, end, transitions, interchanges, and return trip - and should also proactively consider what kinds of things can go wrong along the way, and how to minimise or mitigate against such disruptions.

	Pre-journey planning: these are the decisions about using public transport that are made based on available information.
	Journey start and end: these occur outside the public transport system. For example, travelling from home to the stop, station or terminal along a footpath, and then from the stop, station or terminal to the final destination.
	Public transport stop/station: the dedicated locations where public transport services operate to and from.
	Public transport service: the conveyance that enables the journey, the 'on board experience', as well as the scheduling/routing of services.
	Interchange: places where service or mode transfers take place.
	Return journey planning: reversing the journey for the return to origin or an onward journey to another place.
	Disruption to business-as-usual: this includes planned and unplanned disruption to public transport services or along the journey start and end sections.
	Supporting infrastructure: this supports the journey and includes mid and end of trip infrastructure such as toilets, drinking fountains, wayfinding and seating.

.Figure 17: The eight stages of the Whole-of-Journey (DITRDCA, 2017)

Breaking the trip into its component segments enables planners to target the problematic areas of the journey experience. When consideration is given to whole-of-journey accessibility requirements, the result is that the user is likely to have a more consistent and

reliable experience across the journey. “It only takes one ‘stranding’ or one barrier along the journey for a person to lose confidence with the transport system and to disable further participation” (DITRDCA, 2017). The whole-of-journey approach also provides a useful way to divide a complex system into its component stages, which is helpful in working with stakeholders to identify and rectify the gaps in each element of the journey.

3.5 Collaboration

Article 4(3) of the CRPD requires close consultation with and the active involvement of persons with disabilities through their representative organisations. This should be commenced at the very beginning and continued throughout the process.

Collaboration is a partnership and means that people with disability and other stakeholders are involved in designing, implementing, and analysing or overseeing aspects of the decision. Co-design takes the process of consultation and collaboration a step further, so that relevant stakeholder views contribute not only to the thinking but also the making of decisions. Several frameworks for co-design have been developed and can be found online. One example, the TRIPS *Co-Design Toolkit* (Co-Design for All), is discussed in section 3.5.1. Using a collaborative co-design process can build ownership and engagement with the process. However, it poses some challenges because it takes time to involve people and to ensure that everyone is given an equal chance to participate.

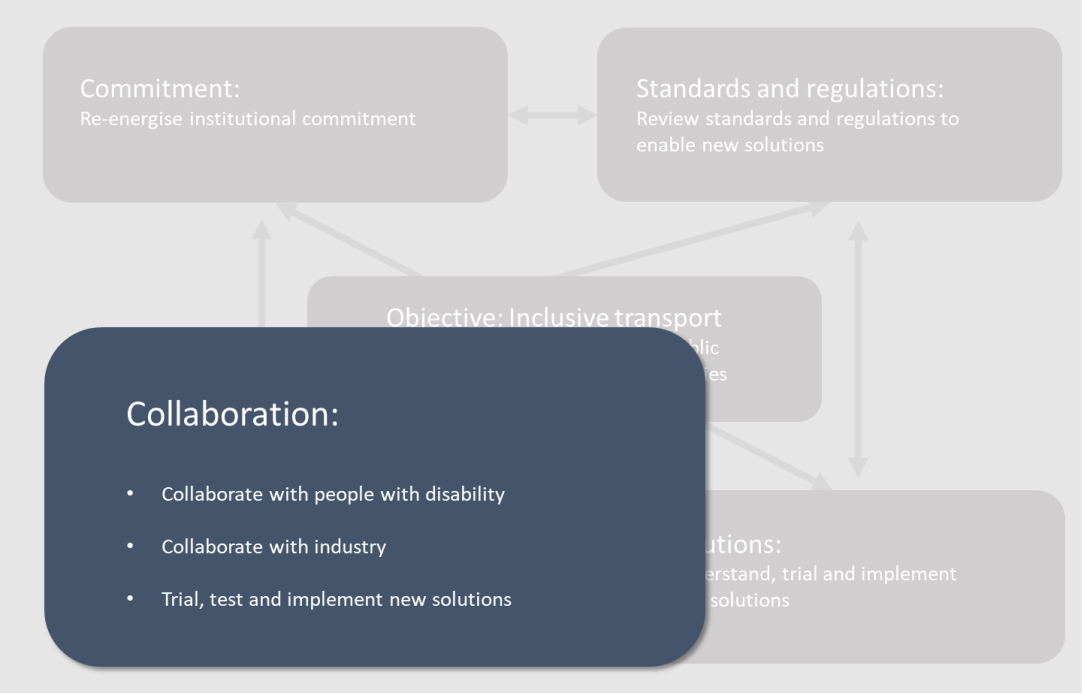


Figure 18: Collaboration

3.5.1 Collaborate with people with disability

People with disability tend to prefer to collaborate using the co-design method. Co-design is about giving all stakeholders shared ownership of a project. Stakeholders may include government authorities, transport manufacturers and operators, regulators, mobility providers, passengers, interest groups, and complementary industry representatives. A participatory, co-design methodology is paramount for accessibility innovation. Most importantly, without the insights provided by travellers with disability, transport designers, planners and operators can make costly mistakes, as it is difficult for people without disability to envision the barriers faced by people with disability. Bridging the gaps in the transport journey requires a holistic view of passenger needs and interactions. A practical approach is

to consider the accessibility issues in each phase of a journey, from planning the journey to arriving at one's destination.

An example of the co-design process can be found in the *TRIPS Co-design Toolkit* (Co-Design-for-All) which was released in 2023 after testing in seven European cities. Each phase of the Co-design-for-All method is based on four iterative stages as shown in Figure 19. Breaking down the complex issue of addressing accessibility into manageable chunks enables the journey to be deconstructed into phases representing the different passenger activities and interactions with the transport system.

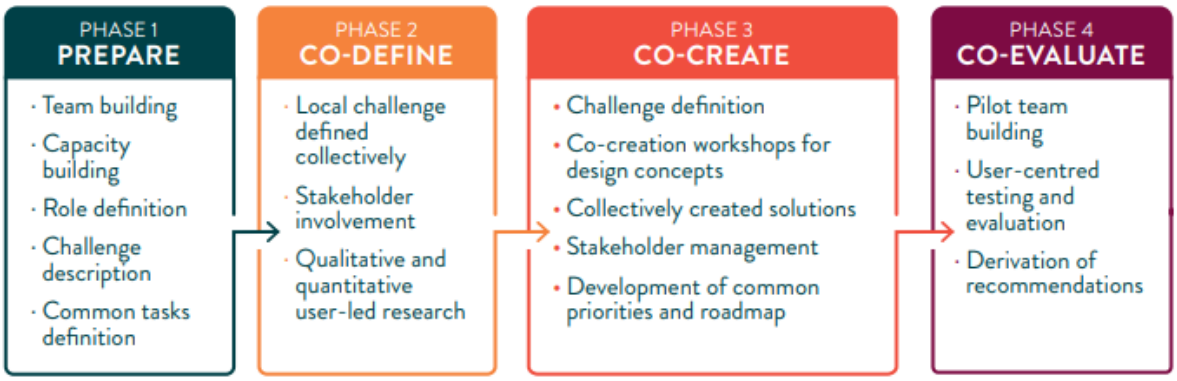


Figure 19: The four phases of the TRIPs Co-Design-for-All methodology (TRIPS, 2023)

TRIPS also offers a free online Co-design course: https://trips-project.eu/deliverables/ (Trips Project, 2020). Co-design can ensure services are a better fit for those who use them, and it enforces a pro-active approach by transport operators involved in the project. However, it requires a long-lasting commitment from all parties. To ensure durability, it should involve raising public awareness to attract new investors and funding for future developments.

3.5.2 Collaborate with industry

The challenge for many economies is to solicit an active interest from private companies to collaborate on improving the accessibility of public transport.
The European Commission regards public-private partnerships (PPP) as a valuable tool to attract additional investment in transport projects. They have linked up with some of Europe's biggest companies to discuss issues relating to accessibility in transportation and recent technologies. These partnerships focused on areas where the market alone has not been able to find a solution quickly, often because the return on investment is not guaranteed (European Commission, 2023).

The US Department of Transportation, through its Build America Bureau, actively encourages private participation in public transportation projects (US DoT, 2021). This is done through a variety of measures such as loans, private activity bonds, and grants. They also offer design challenges focussed on innovative solutions, such as the Inclusive Design Challenge, to enable people with disability to have improved access to transportation. Design teams from academic and research institutions, the business sector, technology companies and analytics firms can compete for cash prizes, with a cap placed on government outlay.

Innovation for people with disability should be positioned as the pinnacle of innovation, 'the place to be,' where inventions are made that eventually improve the experience for all public transport users. This can be enhanced by awards, high profile grants and competitions.

3.5.3. Test, trial, and implement new solutions

Despite significant investment in research and innovation, some technologies do not make the transfer to widespread adoption. There are many factors which impact the successful transition from research to adoption, such as differences in the local economy where public transport takes place including geography, population, policies, and available resources. There is no one-size-fits-all formula for successful adoption of new technologies.

Factors which have been identified as contributing to the success of technology transfer from research to commercial adoption include:

- the careful mapping of user needs
- knowledge about alternative solutions
- planning of implementation pathways
- harmonising existing and new policies within the legal framework
- government support for capacity-building, and
- education and awareness raising. (*TRIPS, 2023 a*)

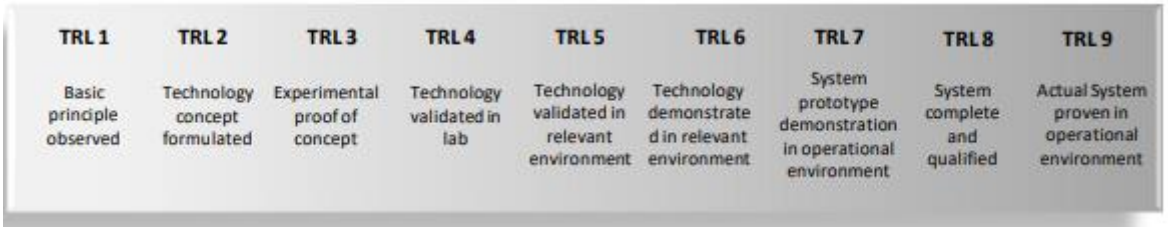


Figure 20: Technology Readiness Levels (TRIPS, 2023 a)

3.5.4 Tips and best practices for research with people with disability

Conducting tests and trials with people with disabilities and older people requires careful planning, consideration, and adherence to ethical guidelines.

The considerations vary from practical 'walking the talk' considerations, such as ensuring that an accessible toilet is available on a test site, to more fundamental considerations such as the adaptation of established research methods and metrics. A common mistake is to assume that people with disability donate their time and expertise for free 'as it is in their own interest'. Just like other research participants, they should be suitably paid for their input.

The document, *Research for all: Making Development Research Inclusive of People with Disabilities, (*authored by CBM-Nossal Partnership for Disability-inclusive Development and Research for Development Impact Network) provides a practical guide for conducting research with people with disability.

Throughout the normal research cycle, this practical document provides tips and suggestions for the inclusion of people with disability.

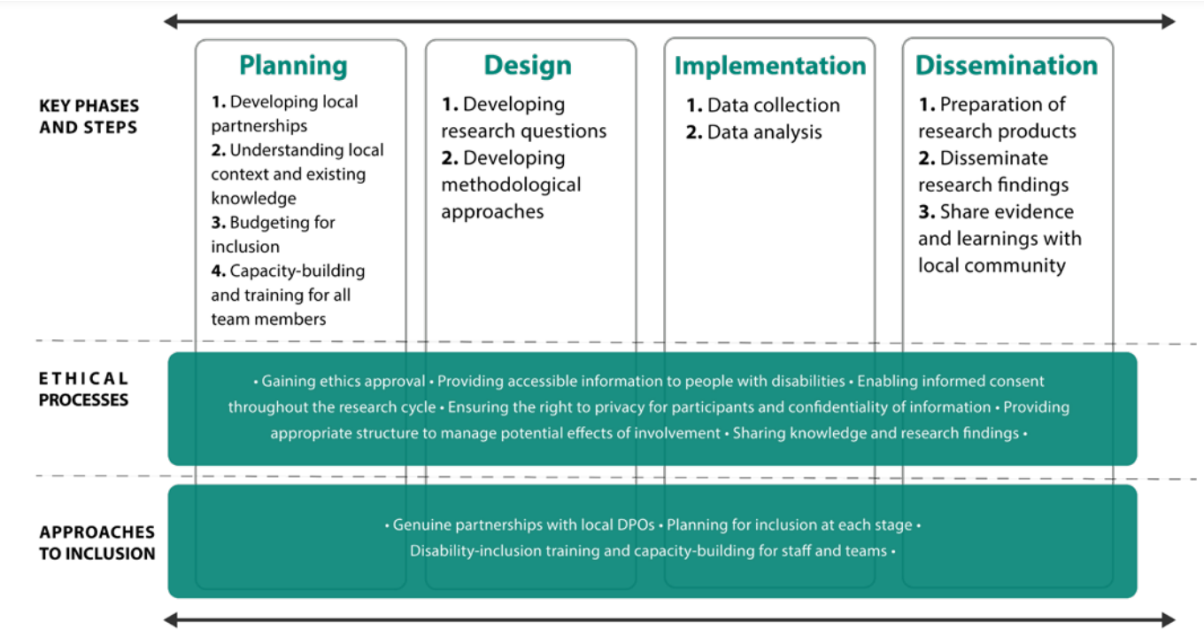


Figure 21: The inclusive research process

Thanks to the participation of the Pacific Disability Forum, a regional peak body that works in partnership with Disabled Persons Organisations (DPOs) in the Pacific region, the guide contains several case examples across APEC (RDI Network, 2020).

4. Conclusions

In this report, we considered the common barriers to transport access for people with disability and older people and discussed the hurdles and opportunities provided by new and emerging transport technologies. We provided principles to guide government policy development in this area. It is hoped that these best practice guidelines will also act as a market signal to industry on the importance of accessibility in the development of future commercial services and products. This document is intended to be used as a starting point for international collaboration between member economies of APEC in improving accessibility and inclusion in public transport using assistive technology.

There is widespread international recognition of the importance of providing more accessible transportation for those with disability. In addition, the world is facing a rapidly aging population, more than half of which will develop some form of disabling impairment as they grow older. New technologies are transforming the transportation experience and creating new challenges. The transport ecosystem needs to be re-assessed to address when, how, and why passengers with different abilities, needs, and access requirements encounter barriers during the transport experience.

Many economies have been discouraged from implementing improvements to transport accessibility for the disabled because they see the option of modifying the existing transport infrastructure as expensive and cumbersome. Several cost-effective strategies for making transport more accessible have been discussed in this report and demonstrate that affordable, accessible transportation is achievable. There are verified economic and social flow-on benefits to economies when those with disabilities and older people can participate in work and recreation, can travel, can access health care, and can do their shopping with similar ease to the general population.

Since 2008, the *Convention on the Rights of Persons with Disability* (CRPD) has provided a useful framework for policy development aimed at improving mobility access for the disabled. The Convention obliges State Parties to adopt universal design principles and to ensure the equitable distribution of new assistive technologies, to identify and eliminate access barriers, to collect and share data, and to develop minimum standards and guidelines for transport accessibility. The CRPD also sets out several requirements for the monitoring and enforcement of obligations to ensure the goals of the Convention are implemented and effective.

Universal design principles, when implemented at the commencement of the design process, can mean that the additional costs of new accessible infrastructure are minimal. Public-private partnerships can mitigate costs, support research, and promote a widespread awareness of the value of inclusive design. When transport standards are designed around the framework of the whole-of-journey concept, they contribute significantly to creating a more universally designed mobility system.

Emerging technologies can be a major force in addressing transportation inequalities. Digitisation provides an opportunity to establish new service offerings based on the available information, both commercially and non-commercially. It can also provide targeted mobility solutions to those with specific needs, something that cannot always be accomplished by

universal design alone. The two elements of universal design and technology combine to work synergistically in boosting transport access.

The consequences of new technology are mainly determined by how the technology is used, rather than the technology itself, so some level of policy and legal intervention is required to ensure that accessibility is given priority in the marketplace. The collection of data is vital for the development of access standards and for devising targeted actions to address access needs. There is currently insufficient standardised, disaggregated data available, and new technologies will provide an opportunity to collect increased amounts of data. However, data collection poses a privacy and security risk, and legislative provisions are lagging in this regard.

There is also a need for government intervention to ensure the benefits of new technologies reach everyone. Certain requirements, such as legal standards relating to the design of new service offerings, may be useful, for example, linking rights for a private company to offer a service commercially with the obligation to ensure adequate accessibility, or by imposing taxes and fees on those services which cause inconvenience to others.

The affordability of devices is still a critical barrier in the adoption of emerging technologies. Issues pertaining to the digital divide should be addressed so that those in lower economic brackets can access smart phones and training in the use of new technology. Optimising access should be part of accessibility legislation and policies, in line with the requirements of the Convention. A lack of access to technology can, in some ways, be mitigated by keeping some traditional alternatives such as paper maps, timetables, and ticketing and continuing to enable people to book over the phone or at the transport stop. Technology can never fully replace the assistance which can be provided by trained transport staff and its effectiveness will be vastly enhanced by a transport system informed by the principles of universal design. Existing indicators on the accessibility of the public transport system fundamentally ignore the users' concern, so at present, their needs and requirements and their prioritisation of mobility issues are not considered. The use of methodologies such as the Mobility Divide Index developed in the European Union's TRIPS study can be used as a set of metrics for auditing the inclusiveness of urban transport infrastructure.

The development of accessible transport standards is necessary in setting the minimal acceptable standard for accessible access to public transport, but they will not be effective unless the implementation of these standards is monitored and enforced. Harmonising transport standards with disability legislation and assigning monitoring, data collection, reporting, and enforcement responsibilities are essential. Basing transport standards on the principles of universal design will ensure that they are as effective as possible and encourage solutions and innovative design beyond compliance.

Consulting, collaborating, and co-designing with stakeholder groups from the outset is foundational to the process of identifying the problems and gaps in the transport system and addressing these systematically through each phase of the journey cycle. The experience of the end user is the ultimate determinant of the usefulness of any emerging technologies, and this understanding should be adopted as a guiding principle.

Helpful resources

Convention:

- United Nations Convention on the Rights of Persons with Disability (2006) www.un.org/development/UNDESA/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

Disability Data:

- Australian Government (2023). *National Disability Data Asset*. https://www.ndda.gov.au/
- Fordham University. Disability Data Initiative reports, 2021, 2022, 2023. Disability Data Initiative - *Advancing the Rights of people with disability* (fordham.edu). https://disabilitydata.ace.fordham.edu/
- Washington Group provides disability inclusion data to the UN. It has templates for surveys, census questions etc. Washington Group Short Set of Questions is used widely in national census. https://www.washingtongroup-disability.com/resources/resources-for-data-users/
- Washington Group (2023). Washington Group on Disability Statistics. *Resources for Data Users*. https://www.washingtongroup-disability.com/resources/resources-for-data-users/
- World Bank Group: on-line course available for free, *Collecting Data on Disability Inclusion*. Video.
- World Bank (2022). *Toward an Inclusive World: Collecting Better Data on Disability*. https://www.worldbank.org/en/news/video/2022/03/05/toward-an-inclusive-world-collecting-better-data-on-disability
- World Health Organisation (WHO) (2017). *Model Disability Survey* (MDS). Survey manual. https://www.who.int/publications/i/item/9789241512862
- WHO Functioning and Disability Disaggregation Tool. FDD11 https://www.who.int/publications/i/item/9789240067479

Disability Access standards

- Australian Human Rights Commission *Review of the Disability Standards for Accessible Public Transport 2002*. Submission to the Department of Infrastructure, Transport, Regional Development, Communication, and the Arts. 11 July 2023 https://www.infrastructure.gov.au/sites/default/files/documents/dsapt-australian-human-rights-commission.pdf
- AHRC, 2023 b. *Guidelines: Equivalent Access under the Disability Standards for Accessible Public Transport 2002 (CT)* https://humanrights.gov.au/our-work/disability-rights/publications/guidelines-equivalent-access-under-disability-standards
- (Australian) Department of Infrastructure, Transport, Regional Development, Communication, and the Arts (DITRDCA), (2017). *The Whole Journey: a guide for thinking beyond compliance to create accessible public transport journey*. https://www.infrastructure.gov.au/infrastructure-transport-vehicles/transport-strategy-policy/disabilities/whole-journey/guide/3-parts-journey
- US Access Board. *ADA Accessibility Guidelines for Transportation Vehicles*. https://www.access-board.gov/ada/vehicles/

Disability Policy

- European Union, (2022). Public Transport and Shared Mobility EGUM Subgroup, 2022. *How to guarantee public transport inclusiveness considering aging, gender, disabilities, and reduced mobility*.https://transport.ec.europa.eu/transport-themes/urban-transport/expert-group-urban-mobility_en
- National Disability Insurance Scheme, (2023). *Australia's Disability Strategy* 2021-2031 https://www.ndis.gov.au/understanding/australias-disability-strategy-2021-2031

Funding and Partnerships

- Build America Bureau website, (2021*). Public-Private Partnerships (P3)* https://www.transportation.gov/buildamerica/sites/buildamerica.dot.gov/files/2019-08/P3_Successful_Practices_Final_BAH.pdf
- Return on Disability Group (ROD) (2023). https://www.rod-group.com/services/
- US Department of Transportation (2016). *Successful Practices for P3s. A review of what works when delivering transportation via public-private partnerships*. Build America Transportation Investment Center. US Department of transportation. https://www.transportation.gov/buildamerica/sites/buildamerica.dot.gov/files/2019-08/P3_Successful_Practices_Final_BAH.pdf

Hidden Disability

- British Standards Institute on Neurodiversity and the Built Environment (2022). PAS 6463:2022 *Design for the mind. Neurodiversity and the built environment*. Guide. https://hdsunflower.com/uk/insights/post/design-for-the-mind-neurodiversity-and-the-built-environment
- Hidden disabilities website. https://hdsunflower.com/au/ .

Universal Design

- Center for Inclusive Design and Environmental Access (CIDA) (2024). *What is Universal Design?* University at Buffalo. School of Architecture and Planning. https://idea.ap.buffalo.edu/about/universal-design/
- Nordic Welfare Centre (2024). *Universal design and socio-economic analyses. A survey of analyses and literature*. Nordic Welfare Centre, Nordic Council of Ministers. 2024 English appendix pp 104-109. https://www.norden.org/sv/publication/universell-utformning-och-samhallsekonomiska-analyser
- Imre Keseru · Annette Randhahn et al. (2023) Towards User-Centric Transport in Europe 3 Making Digital Mobility Inclusive and Accessible. doi:10.1007/978-3-031-26155-8_10, Towards User-Centric Transport in Europe 3: Making Digital Mobility Inclusive and Accessible | SpringerLink

Co-Design

- RDI Network (2020). *Research for All: Making Development Research Inclusive of People with Disabilities.* (Authored by CBM-Nossal Partnership for Disability-Inclusive Development and Research for Development Impact Network) https://rdinetwork.org.au/wp-content/uploads/2020/06/RDI-Network-R4All-Accessible-PDF-1.pdf
- European Commission, *Trips co-design for All toolkit* https://trips-project.eu/co-design-for-all-toolkit/
- Trips Co-design for All Course Co-design for All: doing co-design in practice | Coursera

Data Privacy

- Borges, C., Cooper, R., Schuett, A., and Seehoffer, B., (2023). *Guarding the health data privacy in Europe: The limits and challenges of current regulations*. George Washington University, USA. https://edri.org/our-work/guarding-health-data-privacy-in-europe-the-limits-and-challenges-of-current-regulations/
- Privacy International. *Protecting persons with disabilities in a digitised world.* (2023). https://privacyinternational.org/long-read/5170/protecting-persons-disabilities-digitised-world

Legislation

- Australian Government. Federal Register of Legislation. *Disability Standards for Accessible Public Transport 2002.* https://www.legislation.gov.au/F2005B01059/latest/text
- Canadian Transport Agency Website. *Legislation, regulations, codes of practice, standards, and guidelines.* https://otc-cta.gc.ca/eng/legislation-regulations-codes-practice-standards-and-guidelines
- Forbes, (2022). *13 Tech Areas, Functions and Laws Facing New or Potential Government Oversight.* https://www.forbes.com/sites/forbestechcouncil/2022/05/16/13-tech-areas-functions-and-laws-facing-new-or-potential-government-oversight/?sh=7b9609072f86

Disability access overview

- European Commission, (2023). European Accessibility Resource Centre https://ec.europa.eu/social/main.jsp?catId=1612&langId=en
- UN DESA, (2016). *Good Practices of Accessible Urban Development. Making urban environment inclusive and fully accessible to ALL*. https://desapublications.un.org/publications/sdgs/SDG%2011%20Sustainable%20Cities%20and%20Communities/year/2016
- UN DESA, (2018). *UN Disability and Development Report. Realizing the Sustainable Development Goals by, for and with people with disability.* https://www.un.org/en/desa/un-disability-and-development-report-%E2%80%93-realizing-sdgs-and-persons-disabilities
- UNESCAP, (2022). *A three-decade journey towards inclusion: assessing the state of disability-inclusive development in Asia and the Pacific* 7 December 2022 https://www.unescap.org/kp/2022/three-decade-journey-towards-inclusion-assessing-state-disability-inclusive-development
- The World Bank., (2022). *Disability Inclusion Overview*. World Bank. https://www.worldbank.org/en/topic/disability
- World Bank, (2023). *Foresight and Scenario Planning for Smart Mobility in Latin America and the Caribbean.* Technology & Innovation Lab. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099529001202317209/idu032684e3c0a7f504477095770c84bb5198463
- Oliver Wyman Forum website (2024). https://www.oliverwymanforum.com/mobility/urban-mobility-readiness-index.html

The Digital Divide

- World Bank Group, (2023). *Digital Development. Global Practice*. https://thedocs.worldbank.org/en/doc/b16e2ba1cb754ab47a2dd1b214dd374e-0400062023/original/DigitalDevelopmentBrochure.pdf

The Transport Accessibility Gap

- Motability Foundation, (2022). *The Transport Accessibility Gap. The opportunity to improve the accessibility* (UK). https://www.motabilityfoundation.org.uk/media/iwaidhxk/motability_transport-accessibility-gap-report_march-2022_final.pdf
- Repetto, C et al, (2022). *Developing the multi-dimensional mobility divide index (MDI) as a methodology to assess the accessibility level of public transport systems*. https://open-research-europe.ec.europa.eu/articles/2-143#ref-48

Bibliography

1. Aarhaug, J. (2023) *Universal Design and Transport Innovations: A discussion of New Mobility Solutions through a universal design lens*, Towards User-Centric Transport in Europe 3, pp. 157–172. doi:10.1007/978-3-031-26155-8_10.
2. AusAid, (2013). Accessibility Design Guide: Universal Design Principles for Australia's Aid Program (no date) Australian Government Department of Foreign Affairs and Trade. Available at: https://www.dfat.gov.au/about-us/publications/Pages/accessibility-design-guide-universal-design-principles-for-australia-s-aid-program (Accessed: 18 April 2024).
3. Australian Government Department of Infrastructure, Transport, Regional Development, Communications, and the Arts (DITRDCA), (2017). *The Whole Journey: a guide for thinking beyond compliance to create accessible transport journey.* Available at: https://www.infrastructure.gov.au/infrastructure-transport-vehicles/transport-strategy-policy/disabilities/whole-journey/guide/3-parts-journey (Accessed: 18 April 2024).
4. Australian Government, (2023). *National Disability Data Asset.* Available at: https://www.ndda.gov.au/ (Accessed: 18 April 2024).
5. Australian Department of Social Services (DSS), (2021). *Australia's Disability Strategy, 2021 - 2031*. *Department of Social Services, Australian Government*. Available at: https://www.dss.gov.au/disability-and-carers/disability-strategy Accessed: 18 April 2024).
6. Australian Department of Social Services (DSS), (2022). *Strategy Factsheet*, *Australian Government* | *Disability Gateway*. Available at: https://www.disabilitygateway.gov.au/document/3101 (Accessed: 18 April 2024).
7. Australian Department of Social Services (DSS), (2023 *United Nations Convention on the rights of persons with disabilities*, *Department of Social Services, Australian Government*. Available at: https://www.dss.gov.au/our-responsibilities/disability-and-carers/program-services/government-international/international-participation-in-disability-issues (Accessed: 18 April 2024).
8. Australian Human Rights Commission (2023 a) *Review of the Disability Standards for Accessible Public Transport 2002*. Submission to the Department of Infrastructure, Transport, Regional Development, Communication, and the Arts. 11 July 2023 Available at:https://www.infrastructure.gov.au/sites/default/files/documents/dsapt-australian-human-rights-commission.pdf
9. Australian Human Rights Commission (2023 b). *Guidelines: Equivalent Access under the Disability Standards for Accessible Public Transport 2002 (Cth) Available at:* https://humanrights.gov.au/our-work/disability-rights/publications/guidelines-equivalent-access-under-disability-standards (Accessed 18 April 2024)
10. Borges, C., Cooper, R., Schuett, A., and Seehoffer, B., (2023). *Guarding the health data privacy in Europe: The limits and challenges of current regulations*. George Washington University, USA. Available at: https://edri.org/our-work/guarding-health-data-privacy-in-europe-the-limits-and-challenges-of-current-regulations/ (Accessed 16 April 2024)
11. Build America Bureau (2021). *Public-Private Partnerships (P3) https://www.transportation.gov/buildamerica/p3/library* (Accessed 22 March 2024)
12. Center for Inclusive Design and Environmental Access (CIDA), (2024). *What is Universal Design? University at Buffalo. School of Architecture and Planning*. Available at: https://idea.ap.buffalo.edu/about/universal-design/ (Accessed 1 January 2024)
13. Centre for Universal Design Australia (CUDA), (2021). *Universal Design Position Statement. Plain English Version*. Available at:

https://universaldesignaustralia.net.au/wp-content/uploads/2021/09/Universal-Design-Position-Statement-Plain-Eng-Final-Sept-2021.pdf (Accessed 22 March 2024)
14. Centre for Universal Design Australia, (CUDA) (2023). *Public transport and dementia*. https://universaldesignaustralia.net.au/public-transport-and-dementia/ (accessed August 2023)
15. CfEiU Design, (2023) *The 7 Principles*. Available at: https://universaldesign.ie/about-universal-design/the-7-principles (Accessed 30 June 2023).
16. European Commission, (2024). *Europe's Digital Decade.* Available at: https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade
17. US Department of Transportation. Federal Highway Administration, (2023). *Research Resources Overview.* Available at: https://www.fhwa.dot.gov/publications/research/ear/18066/18066.pdfA (Accessed 18 October 2023)
18. Forbes, (2022). *13 Tech Areas, Functions and Laws Facing New or Potential Government Oversight.* Available at: https://www.forbes.com/sites/forbestechcouncil/2022/05/16/13-tech-areas-functions-and-laws-facing-new-or-potential-government-oversight/?sh=7b9609072f86 (Accessed 13 December 2023)
19. Fordham Institute, (2023). Disability Data Initiative. *Disability Data Report 2023.* Available at: https://disabilitydata.ace.fordham.edu/ (Accessed 12 October 2023).
20. Hanass-Hancock, J., Murthy GVS., Palmer, M., Pinilla-Roncancio M., Rivas Velarde M., Mitra, S. (2023). The *2023 Disability Data Report* Disability Data Initiative. Fordham Research Consortium on Disability: New York. Available at: https://disabilitydata.ace.fordham.edu/wp-content/uploads/2023/06/Main-text-2023_remediated-edited-06-15-2023-1.pdf (Accessed 24 October 2023)
21. Hidden Disabilities website, (2024) https://hdsunflower.com/au/ (Accessed 4 April 2024)
22. IEEE, (2024). *Connecting the Unconnected. An IEEE Future Networks Program*. Available at: https://ctu.ieee.org/what-is-the-digital-divide/ (Accessed 20 April 2024).
23. iMove Australia, (2023). Staff writers. *New/emerging transport tech: Greater accessibility and inclusivity.* https://imoveaustralia.com/project/new-emerging-transport-tech-greater-accessibility-inclusivity/ (Accessed 12 December 2023)
24. Kazou, K, (2017). *Analysing the Definition of Disability in the Convention on the Rights of Persons with Disabilities: Is this Really Based on a 'Social Model' Approach.* International Journal of Mental Health and Capacity Law. Available at:https://doi.org/10.19164/ijmhcl.v2017i23.630 (Accessed September 2023).
25. McCallum, R., (2020). *The United Nations Convention on the Rights of Persons with Disabilities: An Assessment of Australia's Level of Compliance*. Royal Commission into Violence, Abuse, Neglect and Exploitation of People with Disability. Available at: https://apo.org.au/node/308792 Accessed 9 March 2023)
26. Nordic Welfare Centre, (2024). *Universal design and socio-economic analyses. A survey of analyses and literature*. Nordic Council of Ministers. 2024 English appendix pp 104-109. Available at: https://www.norden.org/sv/publication/universell-utformning-och-samhallsekonomiska-analyser (Accessed 23 March 2024).
27. National Disability Services, (2022). *NDS State of Disability Sector Report.* Available at*:* https://www.nds.org.au/about/state-of-the-disability-sector-report (Accessed December 2023).
28. Park, J., & Chowdhury, S., (2021). *Towards an enabled journey: barriers encountered by public transport riders with disabilities for the whole journey chain*. Transport Reviews,

42(2), 1–23. Available at: https://doi.org/10.1080/01441647.2021.1955035 (Accessed March 2024).
29. RDI Network, (2020). *Research for all: Making Development Research Inclusive of People with Disabilities,* (authored by CBM-Nossal Partnership for Disability-inclusive Development and Research for Development Impact Network). Available at: https://rdinetwork.org.au/wp-content/uploads/2020/06/RDI-Network-R4All-Accessible-PDF-1.pdf (Accessed 2 April 2024).
30. Repetto, C. et al., (2022). *Developing the multi-dimensional mobility divide index (MDI) as a methodology to assess the accessibility level of public transport systems*. Open Research Europe. Available at: https://open-research-europe.ec.europa.eu/articles/2-143 (Accessed February 2024).
31. Return on Disability Group (ROD), (2023). Available at: https://www.rod-group.com (Accessed 14 September 2023).
32. The World Bank., (2022). *Disability Inclusion Overview*. World Bank. Available at: https://www.worldbank.org/en/topic/disability (Accessed March 2024).
33. TRIPS Project, (2023 a). *Deliverables. Exploitation Strategy. Available at:* https:-project.eu/wp-content/uploads/2023/03/D8.7-Exploitation-Strategy.pdf (Accessed 12 April 2024).
34. TRIPS Project, (2023 b). *Deliverables*. Available at: https://trips-project.eu/deliverables/ (Accessed at March 2024).
35. United Nations, DESA (n.d.). *Convention on the Rights of Persons with Disabilities - Articles* Available at: https://social.desa.un.org/issues/disability/crpd/convention-on-the-rights-of-persons-with-disabilities-articles (Accessed April 2024).
36. United Nations, (2022). The Economic and Social Commission for Asia and the Pacific (ESCAP). *A three-decade journey towards inclusion: Assessing the state of disability-inclusive development in Asia and the Pacific. Available at:*https://www.unescap.org/kp/2022/three-decade-journey-towards-inclusion-assessing-state-disability-inclusive-development (Accessed October 2023)
37. United Nations, Department of Economic and Social Affairs (DESA), (2016). *Good Practices of Accessible Urban Development. Making urban environments inclusive and fully accessible to ALL. https://desapublications.un.org/publications/good-practices-accessible-urban-development* (Accessed September 2023).
38. United States Department of Transportation, Bureau of Transportation Statistics (2022). *Transportation Annual Statistics 2022.* Available at: https://rosap.ntl.bts.gov/view/dot/65841 (Accessed April 2024).
39. UITP International Association of Public Transport, (2023). TRIPS. *TRansport Innovation for disabled People needs Satisfaction* Available at: https://www.uitp.org/news/trips-project-reaches-the-last-stop-on-the-journey-to-accessible-mobility/ (Accessed April 2024)
40. United States Department of Transportation, Federal Highway Administration (2016). *Successful Practices for P3s. A review of what works when delivering transportation via public-private partnerships*. Build America Transportation Investment Center.Available at: https://www.transportation.gov/sites/dot.gov/files/docs/P3_Successful_Practices_Final_BAH.PDF (Accessed at April 2024).
41. Victorian Government, (2023). *Accessible Public Transport Action Plan 2020-24*. Available at: https://www.vic.gov.au/accessible-public-transport-action-plan-2020-24 (Accessed April 2024).

42. Vuzix, (2020). *Smart glasses could solve global mobility challenges*. Available at: https://www.vuzix.eu/blogs/vuzix-blog/smart-glasses-could-solve-global-mobility-challenges?_pos=35&_sid=1aebf7983&_ss=r (Accessed November 2023).
43. Washington Group, (2023). Washington Group on Disability Statistics*. Resources for Data Users*.
Available at: https://www.washingtongroup-disability.com/resources/resources-for-data-users/ (Accessed February 2024)
44. WeWALK, (2023). *Enhancing the mobility of visually impaired people through a revolutionary smart cane and smartphone app*. Available at: https://wewalk.io/en/ (Accessed August 2023)
45. World Health Organisation (WHO), (2017). *Model Disability Survey* (MDS). Survey manual. Available at: https://www.who.int/publications/i/item/9789241512862 (Accessed December 2023).
46. WHO, (2023 a). *Disability*. Available at: https://www.who.int/news-room/fact-sheets/detail/disability-and-health (Accessed August 2023)
47. WHO, (2023 b) *WHO Functioning and Disability Disaggregation Tool. FDD11: implementation guide 2022 Available at:* https://www.who.int/publications/i/item/9789240067479 (Accessed November 2023).
48. World Bank, (2015). *For Persons with Disabilities, Accessible Transport Provides Pathways to Opportunity*. Available at: https://www.worldbank.org/en/news/feature/2015/12/03/for-persons-with-disabilities-accessible-transport-provides-pathways-to-opportunity (Accessed October 2023).
49. World Bank, (2017). *Implementing the 2030 Agenda. 2017 Update*. World Bank Group Available at: https://thedocs.worldbank.org/en/doc/491561500316509118-0270022017/original/FINALweb2030AgendaUpdate20170713.pdf (Accessed November 2023)
50. World Bank, (2022 a). *Toward an Inclusive World: Collecting Better Data on Disability.* Available at: https://www.worldbank.org/en/news/video/2022/03/05/toward-an-inclusive-world-collecting-better-data-on-disability (Accessed October 2023).
51. World Bank, (2022 b). *Disability Inclusion.* Available at: https://www.worldbank.org/en/topic/disability. (Accessed October 2023)
52. World Bank, Open Learning Experience, (2022 c). *Collecting Data on Disability Inclusion.* Video. Available at: https://www.worldbank.org/en/olc/course/34932 (Accessed November 2023)
53. World Bank Group, (2023). *Increasing Access to Technology for Inclusion*. Available at: https://documents1.worldbank.org/curated/en/099631003072338051/pdf/IDU1116c98a914ebc14dc31a47a1495a00553bae.pdf (Accessed March 2023)
54. Oliver Wyman Forum, (2024). *Urban Mobility Readiness Index* Available at: https://www.oliverwymanforum.com/mobility/urban-mobility-readiness-index.html (Accessed November 2023)
55. United States Department of Transportation. Federal Highway Administration (2016), May 2. *Intelligent Situation Awareness and Navigation Aid for Visually Impaired Persons* Available at: https://highways.dot.gov/research/projects/intelligent-situation-awareness-navigation-aid-visually-impaired-persons. (Accessed December 2023)

Image references

1. Apple, (2022). Apple Live Listen. *Use Live Listen with Airpods or Beats*. Available at: https://support.apple.com/en-au/HT209082
2. AUGANIX, (2023). Smart glasses. *Xander raises $1.4M in pre-seed round to accelerate the launch of its AR captioning glasses.* Available at: https://www.auganix.org/xander-raises-1-4m-in-pre-seed-round-to-accelerate-the-launch-of-its-ar-captioning-glasses/
3. Brown, D., (2017). *Frictionless ticketing. The Ins and Outs Of Fare Gates* Available at: https://danielbowen.com/2017/04/06/fare-gates/
4. Chung, J, (2015). *Be My Eyes App Helps The Blind See, Lets Users Earn Points and Level Up.* Available at: https://www.techeblog.com/be-my-eyes-app-helps-the-blind-see-lets-users-earn-points-and-level-up/
5. Cui, C., (2020). *Flying cars. Indonesia builds a flying taxi that looks like a drone chassis and holds a cabin*. Available at: https://www.linkedin.com/pulse/indonesia-builds-flying-taxi-looks-like-drone-chassis-崔静-cindy-cui/
6. ClickAndGo Wayfinding, (2014). *ClickAndGo „Nextgen" talking signs*. Available at: https://www.clickandgomaps.com/clickandgo-nextgen-talking-signs/
7. Dunbartonshire Chamber of Commerce website, (2023). *Neatebox button. Chamber Member working with Neatebox on Innovative Pedestrian Crossings.* Available at: https://dunbartonshirechamber.com/news-and-events/posts/2020/march/chamber-member-working-with-neatebox-on-innovative-pedestrian-crossings/
8. Hi-techdoor.blogspot.com, (2020). *The edge intelligent future touched by the original AI blind stick.* Available at:https://hi-techdoor.blogspot.com/2020/05/the-edge-intelligent-future-touched-by.html?spref=pi
9. Keolis, (2022). NAVILENS. *An augmented QR code facilitates accessible transport for blind and visually impaired users.* Available at: https://innovation.keolis.com/en/projects-news-insights/an-augmented-qr-code-facilitates-accessible-transit-for-blind-and-visually-impaired-users/
10. Medquor, (2023). Quantum Q'straint self-securement station. *Q'strain releases the Quantum Gen II Wheelchair Securement station*. Available at: https://rehabpub.com/mobility/manual-wheelchairs-mobility-seating/qstraint-releases-the-quantum-gen-ii-wheelchair-securement-station/
11. NTRO, (2023). *Automated ramps. Bridging the gaps at Australian Railway Stations*. Available at:https://www.ntro.org.au/news/bridging-the-gap-in-australias-railway-stations
12. Schieber, J., (2019). *Autonomous wheelchairs. WHILL brings its autonomous wheelchairs to North American Airports*. Available at: https://techcrunch.com/2019/11/20/whill-brings-its-autonomous-wheelchairs-to-north-american-airports/
13. Tomorrow City, (2022). *Digital Zebra. A digital zebra crossing could be the future of our roads.* Available at: https://tomorrow.city/a/smart-zebra-crossing
14. U.S. Department of Transportation, Federal Highway Administration. Public Roads – Winter, (2021), 84(4). *Ped pal* Available at: https://highways.dot.gov/public-roads/winter-2021/technology-make-signalized-intersections-safer-pedestrians-disabilities
15. Visiole (n.d). *Smart Beetle Produits braille et basse vision pour déficients visuels*. Available at: https://www.visiole.fr/basse-vision/braille/bloc-notes-braille/smart-beetle/
16. World Bank, (2022). *Technical Note on Accessibility*. Washington, DC: World Bank. Available at: https://www.worldbank.org/en/topic/disability/publication/technical-note-on-accessibility