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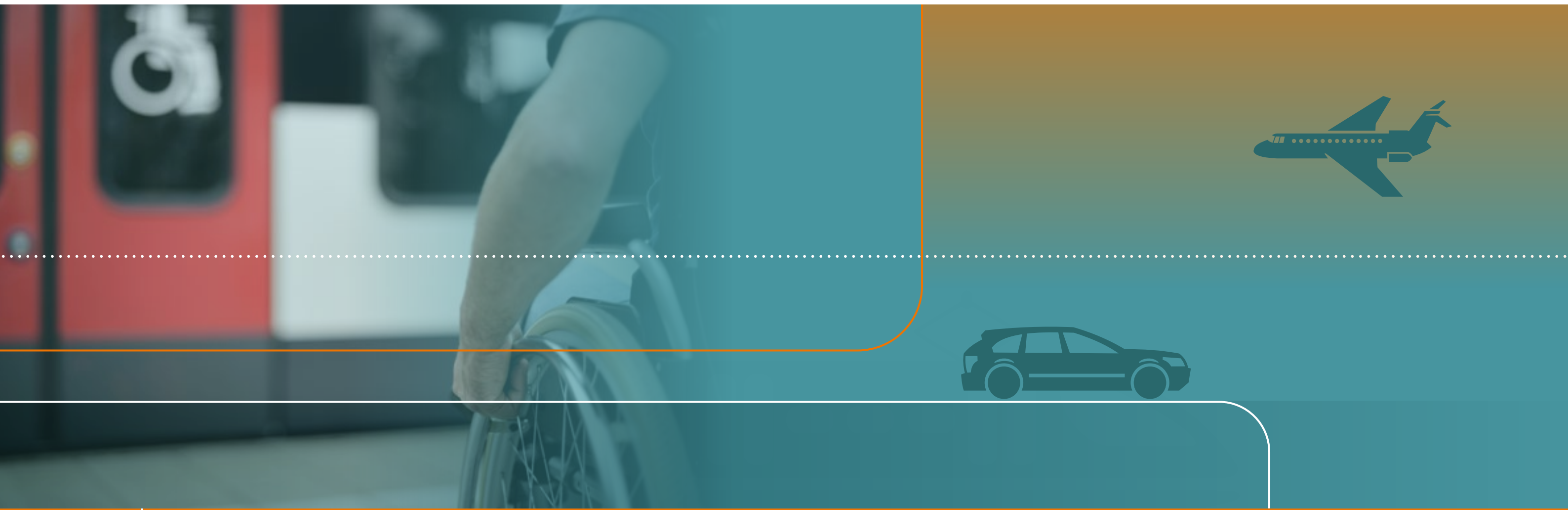

Universal design in transport

Editors: Nils Fearnley and Kjersti Visnes Øksenholt

Preface

The current literature on universal design has so far failed to fully address the challenges faced by transport agencies, and when the planners lack holistic knowledge, the solutions that are developed will not meet the required standard.

The aim of this collection of articles is to contribute to increased overall knowledge about what universal design and accessibility for all entails, and also the principles of how accessibility for all can be achieved in a transport context in terms of the planning process and physical solutions. In this way, the articles will contribute to the realisation of universal design, and thus promote a better quality of life and equality for people with disabilities.

The collection of articles is a topical reference work on universal design for various study programmes, fields of study and postgraduate courses in the higher education sector, and for transport agencies and planning authorities.

We would like to extend a big thank you to Liv Øvstedal and Stein Brembu at the Norwegian Public Roads Administration, who initiated and partly funded the articles, and to the Norwegian Directorate for Children, Youth and Family Affairs (Bufdir) who partly funded the collection through their grant scheme 'Universal design – knowledge development, skills development and information'. A big thank you also to Tanu Priya Uteng from the Institute of Transport Economics (TØI) who took on the role of substitute editor for the first article in the collection, which was written by the editors. And thank you very much to Hanne Sparre-Enger from the TØI's Department of Communication, who edited the texts and led the work on layout and design.

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A collection of articles: Universal design in the transport sector

The aim of this collection of articles is to contribute to increased knowledge about what universal design and accessibility for all entails, as well as principles of how accessibility for all can be achieved in a transport context in terms of both the planning process and physical solutions. We want the collection to strengthen universal design, and in turn contribute to a better quality of life and equality for people with disabilities.

The collection is comprised of seven articles, where this introductory article is Article 1. All shed light on various aspects of universal design in the transport sector.

Article 2. **'Functional requirements for inclusive transport'**, discusses the functional requirements that transport solutions must satisfy in order to facilitate social inclusion of people with disabilities (Bjerkan, 2022).

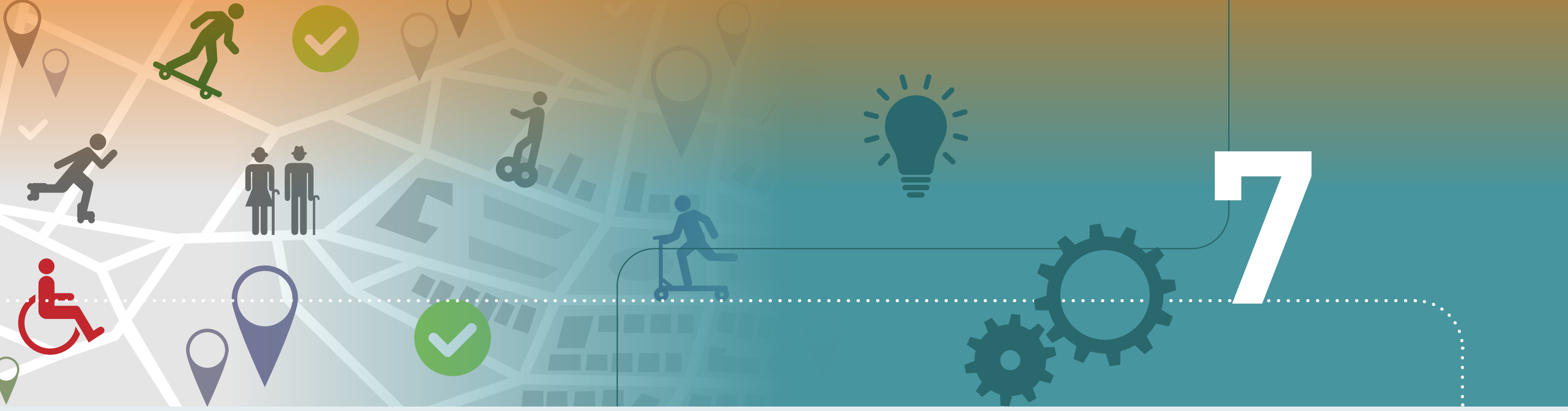
Article 3, **'Universal design and barriers to using public transport**, aims to deepen the understanding of how the transport system is perceived by different groups of people, and to understand and foresee challenges, weigh up the various issues, and facilitate good solutions that benefit as many people as possible (Nielsen and Øksenholt, 2022).

Article 4, **'Universal design and public participation in planning processes**', discusses how universal design can be better safeguarded in the planning process. The article aims to deepen the understanding of the complexity of the planning system, and how this can act as a hindrance for good and holistic solutions (Sjøstrøm et al., 2022).

Article 5, **'How can we ensure universal design of trip chains in a system with complex laws, regulations and responsibilities?'**, gives the reader an introduction to the statutory and organisational framework for universal design in the transport sector, with a particular focus on trip chains. The article discusses how to safeguard universal design of the transport system in a context where legislation and accountability are complex, and reforms alter the distribution of responsibility (Øksenholt and Krogstad, 2022).

Article 6, **'Effects of universal design: quality of life, demand and socioeconomic benefit'**, shows how the utility of universal design for passengers can be measured, and thus also used in cost-benefit analysis, which surprisingly often show that universal design measures in public transport are highly efficient, i.e. they improve social welfare because benefits exceed costs (Fearnley, Veisten and Nielsen, 2022).

Article 7, '**Transport solutions of the future: technology, design and innovation**, describes a selection of new and future transport solutions that are of particular relevance in Norway, and discusses these in the context of what we know about the needs of various user groups. The article demonstrates how new transport solutions are multifaceted and affect the various user groups in different ways (Aarhaug, 2022).



Transport solutions of the future: technology, design and innovation

JØRGEN AARHAUG

In the world of transport technology, most changes bring about better accessibility for more people. Yet technological advances tend to produce both winners and losers. Who wins and who loses will depend on how the new solution is designed and implemented.

This chapter describes transport solutions that are of particular relevance to the Norwegian context[1]. They will be discussed against the background of what we know about the needs of various user groups, as reported by earlier studies on universal design. The aim is to provide insight into the makeup of new transport solutions and how they will affect various user groups differently. The interaction that plays out between the technologies and the frameworks that impact on their adoption determines how the new transport solutions will influence society.

Jørgen Aarhaug

Jørgen studies the issues that affect adoption of new mobility technology. This includes topics like universal design and the regulation of passenger transport markets. Jørgen has a multidisciplinary educational background from the universities of Oslo, Helsinki and Cape Town.

1 This chapter draws on the same original work as Aarhaug (2023) Universal Design and Transport Innovations: A Discussion of New Mobility Solutions Through a Universal Design Lens, in Keseru and Randhahn (eds.) Towards User-Centric Transport in Europe 3. Springer, Cham. doi.org/10.1007/978-3-031-26155-8_10.

1. Introduction

Technological innovations are among the most important long-term drivers of increased affluence and good solutions. In this chapter, transport technology is not limited to accessibility technology, such as navigation aids for the blind. The objective is to highlight the fact that technology is not a neutral entity (Bozeman, 2020). It is a recurring challenge that new technologies, while making us more prosperous, also introduce new exclusions and may maintain extant exclusions. How new technology is adopted, is key. The text refers, in particular, to the needs of people with various disabilities, but the challenges are not restricted to these groups. Good design benefits all.

1.1 The car brought new solutions and challenges

Looking back, the fossil fuel powered private car was one of the most important technological advances of the 20th century, and the most important change within day-to-day mobility. It solved the problem of horse manure in city streets and the technology helped to significantly increase the mobility of individuals. Nevertheless, it also brought new challenges in relation to traffic safety, noise, urban sprawl and consumption of fossil fuels – as well as issues associated with inclusion. Large parts of the population have no access to a private car (Hjorthol, 2016) for reasons of age, health, disability, financial situation or ideology.

The population's relationship with the car changes with time, situation in life, and geography (Lunke, 2022). Bastian et al. (2016) claim that reduced prosperity is at the heart of a reduction in car ownership in parts of the Swedish population. Uteng et al. (2019) look to the importance of life events to explain a change in the take-up of car-sharing solutions. Attitudes also contribute (Nordbakke and Lunke, 2021).

However, a mobility system centred on car use is being challenged from multiple directions, including for its impact on the climate and environment. This has given rise to political targets like the 'zero growth goal, the national strategy to reduce growth in road traffic (Tønnesen et al., 2019). But it also involves general ideas about which narrative tells the story of the good life and the involvement of less-resourceful groups (Nordbakke and Schwanen, 2014; Bjerkan and Øvstedal, 2020; Schwanen et al., 2015). In this context, universal design and mobility solutions for the general public can become increasingly important.

1.2 A window of opportunity for new technology

By challenging the narrative about the private car as being essential to our everyday mobility, we allow new technologies to gain access to the transport system, or existing solutions to be reconsidered and given a new role. This can be seen as a window of opportunity for new technology (Geels and Schot, 2007). Numerous reports have been produced about new transport technologies and their potential, in Norway and abroad, for instance as part of work on the Norwegian national transport plan, which previously assumed, implicitly, that our transport technologies would remain unchanged into the future.

I have based this chapter on work undertaken by the Norwegian Board of Technology to chart the technologies that are expected to influence urban mobility in Norway in the years ahead (Haarstad et al., 2020). A total of 16 technologies were selected for detailed description. These are grouped under the headings of *digital transport systems*, *micromobility, cars and taxis, and public transport*[2]. This list includes new physical transport technologies, such as electric scooters and autonomous cars, as well as new ways of offering transport services, like 'Mobility-as-a-Service' (MaaS)and co-operative intelligent transport services (C-ITS). This article describes a selection of these mobility solutions.

Universal design aims to achieve equality through good design rather than accessibility for specific groups of people. Universal design is not a set of special solutions for various user groups, but one overall solution for as many people as possible.

1.3 Universal design: one overall solution accessible to as many as possible

Universal design is about making the main solution accessible to as many people as possible. The concept of universal design is mainly used in the USA, Scandinavia and Japan, and there are clear parallels to other design philosophies such as 'design for all' (Audirac, 200) and 'inclusive design'. Universal design originated in the 1970s and stems from the architect Mace (1998), who coined the phrase to describe design of the built environment and services. The difference between universal design and accessibility is in the conceptual approach. Universal design aims to achieve equality through good design rather than accessibility for specific groups of people. Universal design is not a set of special solutions for various user groups, but **one overall solution for as many people as possible.** This impacts on the way that user adoption of new technology is perceived.

In addition to the design of the built environment and services, universal design has been used in education, ICT and transport. In the transport sector, it is particularly public transport that has been influenced(Audirac, 2008). Public transport and urban spaces receive considerably more attention in universal design literature that private arenas like cars and private homes. Technological changes in the public transport system are therefore key to the discussion of universal design in the transport sector. This represents a challenge, because many of the technological innovations are aimed at private rather than public transport.

2 Other options would include using one of the following reports, as they also list alternative transport technologies in a Norwegian context: (2018), Kristensen et al. (2018), Kristensen (2019); Bakken et al. (2017)

2. What is new technology?

In this context, new technology is closely akin to innovation and new 'gadgets', and new ways of doing things are indeed included in the concept. One of the important developments in transport-related innovation is the introduction of ICT, which is facilitating or 'general purpose' technology that works across sectors. In practice, this means that much of the innovation has not been about new ways of physically carrying people and goods, but about the way that physical transport is communicated.

'New technology generally increases the window of opportunity for action. Yet, this does not necessarily mean that everybody will be faring better.'

New technology generally increases the window of opportunity for action – making it possible to do more. However, this does not necessarily mean that everybody will be faring better. The technology and how it is adopted are not neutral entities. The fact that the pie is getting bigger, does not mean that everyone gets a larger slice. New technology normally produces both winners and losers, and the same person can be a winner as well as a loser measured against different parameters. It is not a foregone conclusion that those who benefit the most from the new technology will want to, or are in a position to, compensate those who fare worse for the losses they incur.

New technology is also not necessarily neutral in terms of distribution and inclusiveness. When a new technology enters the market, the way it is adopted is not a matter of chance, it is a result of decisions.

2.1 Who are the first to adopt new technology?

Innovation literature describes several models that demonstrate how new technology spreads and is adopted by the populations. Rogers' model (2010, 1962) is a classic example, which is also the most frequently used. In this model, new technology spreads like an S-curve. This makes the distribution of its adoption look like a normal distribution curve, where those who are first to adopt the new technology are typical 'trend setters', i.e. the 'urban elite' who can afford to invest in a flop. Thereafter, the technology is gradually adopted by the rest of the population.

In this model, the uptake of new technology spreads like an S-curve. This makes the distribution of its adoption look like a normal distribution curve, where those who are first to adopt the new technology are typical 'trend setters', i.e. members of the 'urban elite' who can afford to invest in a flop. Thereafter, the technology is gradually adopted by the rest of the population.

In the context of universal design, Rogers' model poses some challenges, one of which is the fact that new technology is often aimed at 'the elite'. The idea that a few people make use of the solution before it is adopted by the rest of the population, is not necessarily a problem. However, if the elite's consumption cannot be replicated, access to mobility will soon become worryingly unequal. For example, new transport solutions may require a certain type of smartphone (which is the case for some ride-sharing services), payment by credit card (which is the case with many international companies), a good financial position or a driving licence (car sharing). All these examples include components that large parts of the population cannot access3. Any new technology which is useful only to some, is not universal.

It may be difficult to avoid such bias. Many new mobility technologies on the market were aimed at typical 'early adopters', whose demographics tend to overlap with those of the originators. Also, many of the new technologies are being developed in and

3 As an example: Access to credit cards require a valid ID, the legal ability to give consent for transactions and credit rating, all of which excludes persons, who still may require access to mobility.

for a global market and any user involvement is limited to the question of how the technology should be adopted in Norway rather than what is included in the solution.

2.2 What is new technology? Examples

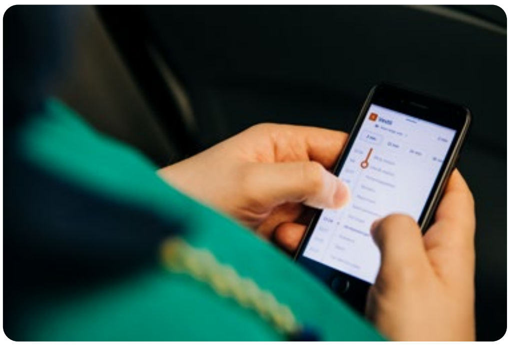


Photo: Ruter As. Nucleus AS, Magnus W. Sitter

The work undertaken by the Norwegian Board of Technology to chart technologies that are expected to influence urban mobility in Norway describes 16 new technologies. These are here grouped under the headings of *digital transport systems*, *micromobility, cars and taxis, and public transport.* All of these groups have been affected by the development of digital technology. These are technologies that tend to be categorised as being part of the fifth industrial revolution (Perez, 2003). Somewhat simplified, digitalisation can be described as the process of adopting digital technology. Digitisation is an important component in this process – i.e. that information is no longer handled as atoms but as bits (Negroponte et al., 1997). This means that the transmission of information is detached from the transfer of physical entities, which in turn opens the door to an array of new services and offers up existing services in new ways. Information that used to be difficult to access, like where the bus is, can be made available at a low cost and can provide more reliable information on board the bus, at bus stops and to passengers.

'Digitalisation is the process of adopting digital technology'

Therefore, digitalisation facilitates new commercial and non-commercial services based on available information. For instance, the information can be combined with promotions for the various transport services, or included on ticket-buying platforms. This allows people to make better informed choices about when, where, and how they wish to travel. At the same time, this can widen the divide between those who have access to this information, for example through their smartphone, and those who have not.

The fact that information can give more people access to better services if they can pay for them, raises a philosophical question:

2.3 Hva menes med «hovedløsningen»?

'Or is it enough that everyone has equal access to a minimum level of mobility?'

Does this mean that the overall transport system should provide mobility for all, or does it mean that each element of the transport system must be accessible to as many people as possible? Or is it sufficient that everyone has equal access to a minimum level of mobility?

The technologies that Haarstad et al. (2020) found to be most relevant, are listed in table 1.

Table 1. Relevant new mobility technologies, based on Haarstad et al. (2020).

TECHNOLOGY	STATUS	EXAMPLES	RELEVANCE TO UNIVERSAL DESIGN
Digital transport systems			
Mobility platforms/ MaaS	Pilot / scaleup	Whim, UbiGo, various apps / projects linked to major public transport operators	Considerable
Satellite-based road pricing	Ready, not implemented		Little
C-ITS (generic term for co-operative ITS)	Different stages	Geo-fencing, beacons	Considerable
Micro mobility			
E-bikes and small vehicles	Established	E-bikes, e-scooters, cargo bikes, unicycles, segways etc.	Noe
Shared micromobility	Established	VOI, TIER, BOLT, Ryde, oBike, ofo, Urban Sharing, etc.	Some, mainly due to misuse
Autonomous micromobility	Experiment		Potentially considerable
Cars and taxis			
E-cars	Established	BEVs from most manufacturers	Some
Car sharing	Established	Bilkollektivet, Hertz car pool, Hyre, hire companies	Some
Taxi-apps	Established	Taxifix, Uber, Bolt, Mivai, Yango, Grab, Didi	Some
Ride sharing	Established	GoMore, Samme vei	Little
Autonomous cars	Pilot	Waymo, Cruise	Considerable
Taxi drones	Pilot	EHang	Little
Public transport			
Demand-responsive buses	Established	Flex, pink buses, HentMeg etc.	Considerable
Autonomous minibuses	Established		Considerable
Autonomous bus fleets	Pilot		Little
Autonomous ferries	Pilot		Little

The technologies that are considered to have some or considerable relevance to universal design are discussed in detail below.

2.4 Digital transport technologies

Mobility platforms (MaaS / combined mobility) are digital platforms that combine the services of several different modes and operators in a single user interface, often made available through a mobile phone app. The main challenges for this technology have so far revolved around its implementation. The technical problems have proved simpler to solve than the organisational ones (Smith and Hensher, 2020). At the time of writing (2021), there is a multitude of experiments and services that can be characterised as MaaS but none of them play a key role in an established transport market. I am not familiar with any studies of MaaS from a universal design perspective. In principle, because MaaS reduces information barriers, the platforms should increase the public's opportunity to use a given transport service. MaaS makes it possible to receive better information about existing services and the extent to which they are available. The downside is that existing MaaS platforms require users to have a certain digital competence, the ability to pay online and access to a smartphone. If a public transport system is based on MaaS, fragmentation of responsibilities is a potential challenge in that it is unclear who is responsible for, say, wheelchair accessibility when the operator no longer has a direct relationship with the passenger.

'Mobility platforms (MaaS / combined mobility) are digital platforms that combine several different transport modes and operators in a single user interface, often made available through a mobile phone app'

Cooperative Intelligent Transport Systems (C-ITS) include technologies that enable vehicles to communicate with each other and with the infrastructure, and that are connected in a system. This is a set of technologies that over time may deliver more interconnected transport systems and more automation. This can make the transport systems more universally designed over time, through access to more and better information about what is happening in the system. One example is geofencing. This technology can create mobility zones, for example to regulate speed and parking restrictions for e-scooters, introduce zero emission zones, etc. 'Beacons' are another example that can make time and location-specific information about transport services accessible to the blind.

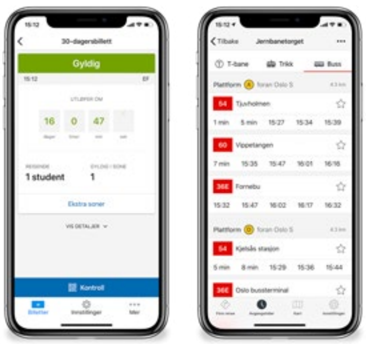


Photo: Ruter As. Ruter Designsystem

2.5 Micromobility

E-bikes and other small vehicles are referred to as 'micromobility'. This term covers a wide range of different initiatives, including cargo bikes, e-scooters and segways. Several of them can be used in mixed traffic lanes with pedestrians. To the extent that these modes replace cars, vans and lorries, they can make things easier for other road-users, but they will also increase the pressure on areas that are currently designated for walking and cycling.

E-bikes allow more people to cycle, and more people to cycle farther (Fyhri and Sundfør, 2020). This makes the bike a more universal mode of transport. E-scooters give access to motorised mobility for many who previously had no such access in real terms. From a universal design perspective, the parking of e-scooters when not in use has attracted significant attention. The fact that these small vehicles are abandoned on pavements and get in the way of wheelchair users can be hazardous for the blind and the partially sighted (Karlsen et al. 2023).

'Shared micromobility includes bicycles, e-bikes and e-scooters that are available for hire through a subscription or per trip.'

Shared micromobility includes bicycles, e-bikes and e-scooters that are available for hire through a subscription or per trip. Detaching ownership from use lowers the threshold for adopting the technology and is expected to improve access for more people. However, the majority of users are young, able-bodied people who travel within town centres (Fearnley et al., 2020). There are also vast regulatory challenges associated with free-floating systems, where bikes and e-scooters have no set endpoints(Fearnley, 2020; Sareen et al., 2021; Yin et al., 2019). Other challenges associated with space use and littering have caused the introduction of various local byelaws and nationwide regulations.

Autonomous micromobility involves small driverless vehicles. This technology is still at prototype stage but can potentially help to solve some of today's micromobility challenges by making motorised mobility accessible to more people. For example, people who cannot currently access services because they have no driving licence, will be able to make use of a driverless service. Potentially, this could also contribute to solving the problem of abandoned bikes in that the vehicles can park and reposition themselves. Yet this will not solve many of the other challenges posed by existing shared micromobility schemes, e.g. how people who are not young and able-bodied can make use of the service.

2.6 Car-based mobility

Electrification makes the car fleet more eco-friendly and makes the car more easily available for many[4]. In itself, this is of little consequence in relation to universal design and accessibility. However, EVs can serve to illustrate how new technology is introduced onto the market without universal design being taken into consideration. The first EVs were only able to meet the needs of a small proportion of the population because only a few models were available, all of which had a short range, and there were very few public EV charge points, etc. As the technology developed, more models were introduced to cover a wider range of needs (Figenbaum, 2020; Figenbaum et al., 2015).

Nevertheless, charging an electric car, and particularly fast charging, requires a relatively able-bodied person to handle the charger. Car sharing gives more people access to a car without having to personally own one. This may reduce car ownership, demand for parking facilities, and emissions to the urban environment (Chen and Kockelman, 2016). This can free up areas for other groups of road users and may have a positive impact on accessibility. However, it is not entirely clear what effect car sharing will have in the longer term because the patterns of use and participant motivation are still being moulded (Julsrud and Farstad, 2020). The impact of car sharing on universal design, is also uncertain. Car sharing is aimed at people who are able to drive standard-design cars and excludes those who cannot use this type of vehicle. Car sharing can therefore be said to widen the divide between the 'included' and the 'excluded'.

'Charging, and particularly fast charging, requires a relatively able-bodied person to handle the charger'

Taxi apps make a variety of transport services available via smartphones. How this may change accessibility to the transport system is up for discussion. Taxis are already the most accessible mode of transport. On the one hand, the apps provide easier access to taxis. For many users, their sense of safety is also boosted. On the other hand, the business models associated with the apps have many cases resulted in the de-professionalisation of taxi services and restricted the opportunity for local authorities to impose vehicle-specific requirements (Oppegaard, 2020). One outcome is that a lower number of cars are wheelchair accessible (Oppegaard et al., 2023).

4 This statement is not necessarily true in non-Norwegian contexts.

This raises the question: Is it enough that every operator has access to a number of vehicles adapted for people with various disabilities, or should every vehicle need to meet the requirements? The latter will involve considerably higher costs.

Autonomous or automated vehicles are a potential 'game changer' in the personal transport market. It is the Board of Technology's opinion that this technology will first affect the taxi market (Seehus et al., 2018). Autonomous vehicles are expected to make car-based mobility accessible to a larger section of the population and thus considerably boost the level of mobility, particularly for those who currently have no access to a car. The impact on other modes may also be dramatic, with significant increases in transport quantities and energy consumption as potential negative consequences. There are also important questions linked to how self-driving technology will be adopted, and the outcomes will largely depend on how these questions are answered (Nenseth et al., 2019; Kristensen, 2019).

'A car-sharing service is aimed at people who can drive a standard-design car and excludes people who cannot use this type of car'

2.7 Large vehicles

Demand-responsive buses (often bookable by smartphone) are closely related to MaaS and can help to make mobility accessible, thereby having a positive effect on universal design (Nordbakke et al., 2020). However, some studies, such as Skartland and Skollerud (2016), show that it is difficult to communicate flexibility, and that flexibility is perceived as an uncertainty, which has a negative effect on universal design. Like other services that are based, to a degree, on automated processing of bookings, various forms of demand-responsive bus services may have the same weakness as taxi apps in that some potential user groups are excluded.

> *'Is it enough that each operator has access to a number of vehicles adapted for people with various disabilities, or should every vehicle need to meet the requirements?'*

Autonomous minibuses can, once the technology has developed a little further, help to create a better integrated and wider reaching public transport system that provides a timetabled near door-to-door service. It is highly likely that autonomous minibuses can be designed in a way that satisfies normal requirements for universal design because they are generally expected to be used in the publicly funded public transport system. This will allow the public sector to specify the design of the vehicles in accordance with universal design requirements. The accessibility of autonomous buses is likely to be better than for existing buses, provided there is a service assistant aboard the vehicle. Autonomous buses should certainly be cheaper to operate than conventional ones, so that more vehicles can be made available to the public at the same cost while providing a better service.

It is the case for all the new technologies that innovations generally focus on putting features and services together in new ways. In the period 2010-2020, the opportunity to create better user interfaces through smartphones was particularly important. If we look ahead to the coming decade, it appears that driverless and emission-reducing technology will become more important. If driverless technology is adopted much more extensively than today, this will impact significantly on the way that many people think about transport and mobility for all. This is a popular field of research, but there is still considerable uncertainty. Like other scholars, Seehus et al. (2018) point out that the outcomes will depend on the frameworks that are put in place for driverless technology and its adoption.

'When the technology has developed a little further, autonomous minibuses will provide a better integrated and wider reaching public transport network and a timetabled door-to-door service'

2.8 What are the consequences of new technology?

Lenz (2020) points out that aside from the obvious benefits of better information flow and better access to information about transport services, many aspects associated with new transport technology and smart mobility remain unclear. For example, data flow across systems gives rise to new challenges with respect to risk, ownership and responsibility.

Photo: Ruter As. Nucleus AS, Daniel Jacobsen

Many aspects of new mobility technology affect people differently. In many ways, this new inequality is perceived as under-communicated. Typical users of new mobility services are described by Lenz (2020) as having many characteristics in common with the typical early adopters described by Rogers (2010, 1962): they are young, well-off, technology-minded and able-bodied.

'Typical users of new mobility services are young, well-off, technology-minded and able-bodied'

Depending on the up-take speed of in the rest of the population, the included population segments could either grow or diminish. Optimistic expectations suggest that greater mobility will be accessible to more people. Pessimistic expectations suggest growing differences between people, because some will win access to better mobility while others will retain their current mobility, or lose some of the mobility they currently have.

However, there are numerous examples of user involvement with the development and implementation of new technology in the transport sector, particularly in respect of public transport. Such user involvement is a statutory requirement and is often considered a positive initiative (Skartland and Skollerud, 2017). Examples include Ruter's work on journey planners and age-friendly transport. Navigation aids for the blind on smartphones, and contactless payment by mobile phone make it possible to avoid ticket machines and parking challenges.

It appears that the consequences of new technology largely depend on the way that the technology is adopted, i.e. what frameworks and regulations are introduced rather than simply the technology as such. The window of opportunity increases, but not necessarily for all.

Photo: Ruter As. Redink, Thomas Haugersveen

3. New possibilities – new challenges

3.1 What about the people who are excluded?

Studies of travel behaviours often find that people with disabilities travel less than the rest of the population (Nordbakke and Schwanen, 2015; Aarhaug and Gregersen, 2016; Gregersen and Flotve, 2021). People with disabilities experience a variety of barriers to transport (Bjerkan, 2009; Bjerkan et al., 2011) associated with long distances (Lodden, 2001; Nordbakke and Hansson, 2009), design (Aarhaug et al., 2011), maintenance (Aarhaug and Elvebakk, 2015), etc.

'People with disabilities travel less than the rest of the population'

A universally designed transport system is not a transport system that has been adapted to meet the special needs of a few. Some features that have been introduced to make the transport system more universally designed generally make all users rate the service higher, like step-free access to public transport vehicles, real-time information, automatic bus stop information and waiting shelters with seating (Veisten et al., 2020; Flügel et al., 2020; Nielsen et al., 2018). There is no contradiction between sensible socio-economic investment and universal design, rather to the contrary. To some extent, this is challenged by new technology.

Photo: Ruter As. Redink, Fartein Rudjord

The main trend is for people to opt for private transport the higher their income and affluence (Kristensen et al., 2018). This has no immediate bearing on universal design as new services are added to existing ones. But the indirect impact of this trend is potentially considerable, in that it may undermine the funding models for public transport solutions which largely ensure that mobility is made available to as many people as possible. Aarhaug and Elvebakk (2015), Øksenholt and Aarhaug (2018) and others, studied the introduction of digital ticketing by way of an example.

Bus tickets were previously bought for cash from the driver who issued paper tickets with printed text and a stamp. This system ensured that passengers talked to the bus driver, who therefore knew where they were travelling to, and drivers could be made aware of any special needs that passengers might have, so that these could be accommodated.

This system was replaced by electronic tickets on proximity cards to be bought in advance of travel and validated on a pole aboard the bus. This created challenges for several user groups. The partially sighted (and people with other disabilities) found it very difficult to use the ticket validators. Points were also made about the uncertainty associated with recording of use and the validity of tickets. County and municipal authorities had chosen to grant free public transport to people with disabilities. One study shows that only very few of the people concerned had received this information and therefore were not aware of the offer. Consequently, the new ticketing system was perceived to be a barrier to use, although there was in fact no need for people with disabilities to relate to the ticketing system at all (Øksenholt and Aarhaug, 2018). It can also be questioned whether the decision to allow free travel for the partially sighted is good universal design rather than an exclusion mechanism. The proximity cards have later been supplemented with smartphones as ticket carriers, in most cases this does not influence the accessibility of the ticket.

Photo: Ruter As. Redink, Hampus Lundgren

3.2 Categories of challenges

The mobility impaired

For people with mobility impairments many transport-related innovations are good news. Better access to e-bikes can widen the radius of action for those who can use them. More demand-responsive public transport services facilitate door-to-door travel for more people, particularly where the feeder leg of the public transport journey used to represent a barrier to travel. Increased access to car-based services is also a positive in terms of participation – provided the people with impaired mobility have an opportunity to avail themselves of the offer.

A transition from bus-based services to car-based services can represent a challenge for wheelchair users, as this may reduce access to wheelchair-accessible vehicles. Another challenge is represented by the parking of shared-use e-scooters in public spaces in town centres, as this can constitute physical barriers.

The navigationally impaired

The digitalisation of information has generally helped to make travel much simpler for the navigationally impaired. Awareness about how information is communicated, and access to information on various platforms such as digital posts, automatic announcements, and on mobile phones, make the journey a better experience. The same goes for greater access to door-to-door transport services. Some studies have identified weaknesses with the implementation of the more sophisticated information systems. These are generally minor flaws in a development which is largely positive.

The visually impaired

For the visually impaired, many of the services offer increased access to door-to-door transport. This can be very useful. It is expected that this will improve even further when driverless transport is more widely introduced. This will see the removal of several (but not all) mobility barriers currently encountered by the visually impaired. The digitalisation of information about features on board public transport vehicles has already helped to reduce the barriers for the blind and partially sighted. It is a challenge for the partially sighted that new transport solutions, particularly micromobility, increases the speed of traffic in pedestrian areas and involves heavier vehicles (e-scooters are heavier than manual kick scooters, e-bikes are heavier than manual bikes, etc.) This increases the risk of accidents and the severity of such accidents. Moreover, several of the new transport services are only available through smartphones and apps, which can be challenging for the partially sighted.

Poverty

The fact that increased affluence generally leads to increased use of private transport solutions poses an inherent structural challenge from within the transport system. Several consequences of this fact impact on universal design. The revenue base for shared solutions is reduced when fewer people pay for tickets. In Norway, the severity of this impact is reduced by the use of toll fees and ordinary taxes to cover the cost of operating a public transport network. These monetary transfers from car users to public transport users disincentivise car travel and help to maintain a better public transport system than what user payments alone can pay for. However, as a redistribution policy instrument this system has only limited impact (Fearnley and Aarhaug, 2019).

It is a challenge that many new technologies involve considerable cost to the user. This can negatively influence the overall level of mobility in two ways: 1) Those who cannot afford the new technology will not have access to the increased mobility it brings. 2) When parts of the population transition to new mobility solutions, which are often private and user funded, this undermines the revenue stream that funds mobility solutions that others depend on.

3.3 How does new technology affect universal design?

More generally, there are several aspects of new technology that pose a problem when seen against the objective of a universally designed society. How new technology affects efforts to achieve universal design, will largely depend on the way that the new technology is adopted. This is a big and complex question. New technology clearly increases the window of opportunity. However, the capacity to adopt new technology is unevenly distributed. The introduction of new technology can therefore create new barriers, whether of a physical, technical, financial, or psychological kind. The practical implications stem not only from the qualities of the particular new technologies; they are also an outcome of how these technologies are adopted. Many of the innovations that have been introduced, particularly in the field of public transport, have made transport services considerably more accessible, e.g. real-time information systems, mobile ticketing and step-free access. Value estimation studies also show that these are interventions that most users benefit from, which aligns with the idea of universal design.

'The introduction of new technology can create new barriers, whether of a physical, technical, financial or psychological kind'

If we look back on the period 2010-2020, new technology has significantly improved the universal design of the transport system, particularly in the field of public transport. The digitalisation of information systems is an important contribution. We no longer need access to a physical timetable to check bus times; the information is available everywhere. And while it used to be impossible to know when the bus would actually arrive given the current traffic situation, as opposed to when it was scheduled to arrive, this is now possible thanks to real-time systems and the fitting of GPS on buses. This is a big advantage. The technology has also facilitated the display of far more reliable information for passengers aboard the bus, with automatic bus stop announcements and information screens. These interventions are highly appreciated by all passengers (Veisten et al., 2020).

Photo: Ruter As. Fotograf Birdy, Birgitte Heneide

4. Conclusion

New technology has helped to make transport, and particularly public transport, accessible to a larger proportion of the population. This means that society, at least with respect to the transport sector, is moving towards universal design. New technology helps to facilitate this development. As a consequence, there is an increased level of mobility, and more people have greater opportunities to contribute to society.

If we look to the future, several transport technologies that are currently niche, may potentially further strengthen developments towards increased mobility for more people. Autonomous motorised vehicles in a mixed transport system clearly have the greatest potential. This technology may be able to make mobility, at the level currently available to car users, accessible to more people. This will lead to enormously increased opportunities for people with disabilities. However, if we use different parameters there is also potential for disaster.

Model studies show that autonomous cars can help to reduce transport volumes. However, to achieve these results, the assumptions used in the models tend to be severe and unrealistic, like being able to force users away from private solutions and compel them to share, in a way which is currently unfeasible. When the same models are run with less rigorous assumptions, the scenarios become far less attractive from an environmental and social perspective (Nenseth et al., 2019; Kristensen, 2019). Yet again, the question is how the opportunities provided by the new technology are used.

If we look back on the latest decade, we have seen large-scale implementation of numerous new technologies that have sought to make public transport more user-friendly, e.g. real-time information systems, traffic information apps, step-free access, mobile phone tickets, automatic bus stop announcements. While many of these technologies were motivated by universal design, they have made the journey better for all.

If we look back on the 2010s, we have seen large-scale implementation of numerous new technologies that have sought to make public transport more user-friendly, e.g. real-time information systems, traffic information apps, barrier-free access, smartphone tickets, automatic bus announcements. Often, technologies that were motivated by universal design have helped to improve the journey for everyone.

While earlier research shows that universal design measures have provided significant socio-economic benefit, the same research shows that accessibility is not necessarily prioritised by commercial operators unless they are required to do so. This produces a set of political balancing acts. The legal framework, whether national or EU-wide, can serve as a tool to increase the benefit for all. Operators are forced to choose the solutions they ought to choose were their objective to maximise societal welfare.

> *'If new technologies like taxi apps, autonomous cars and e-scooters are to make the transport system more accessible to as many people as possible, in line with the idea of universal design, then regulations are needed.'*

If new technologies like taxi apps, autonomous cars and e-scooters are to make the transport system more accessible to as many people as possible, in line with the idea of universal design, then regulations are needed. At the moment, it appears to be financially unviable for providers of new transport services to make these accessible in the way and at the level required to be compatible with the idea of universal design.

To reach the objectives of universal design, statutory regulations must seek to distribute the benefits of new technology in a way that enables people to take advantage of them even if they are not typical early adopters of new technology. This can be achieved by making stipulations for the design of new services, e.g. by linking the right to offer a commercial service to a duty to provide adequate accessibility, or by taxing services that inconvenience others and using the revenue to meet the mobility needs of those who cannot take advantage of the new technology.

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