Rethinking engagement in urban design: reimagining the value of co-design and participation at every stage of planning for autonomous vehicles.

BELKOURI, D., KHAIRY, L., LAING, R. and LANNG, D.B.

2023

emerald PUBLISHING

Archne
International Journal of Architectural Re

Rethinking engagement in urban design: reimagining the value of co-design and participation at every stage of planning for autonomous vehicles

Journal:	*Archnet-IJAR: International Journal of Architectural Research*
Manuscript ID	ARCH-04-2023-0110.R1
Manuscript Type:	Research Paper
Keywords:	Urban design, Autonomous Vehicles, participation, co-design, people, case studies

Rethinking engagement in urban design: reimagining the value of co-design and participation at every stage of planning for Autonomous Vehicles

Abstract

Purpose

The practical demonstrations and research which led to the preparation of this paper involved a combination of stakeholder engagement, policy debate and the practical demonstration and testing of autonomous vehicles. By adhering to a design approach which in centred on participation and human-centred engagement, the advent of autonomous vehicles might avoid many of the problems encountered in relation to conventional transport.

Design

The research explored how a new and potentially disruptive technology might be incorporated in urban settings, through the lens of participation and problem-based design. The research critically reviews key strands in the literature (autonomous vehicles, social research, participatory design), with allusion to current case study experiments.

Findings

Although there are numerous examples of AV research concentrating on technical aspects alone, this paper finds that such an approach appears to be an unusual starting point for the design of innovative technology. That is, AVs would appear to hold the potential to be genuinely disruptive in terms of innovation, yet the way that disruption takes place should surely be guided by design principles, and by issues and problems encountered by potential users.

Originality

What sets this research apart from other studies concerning autonomous vehicles was that the starting point for investigation was the framing of AVs within contexts and scenarios leading to the emergence of wicked problems. It begins with a research position where the potential uses for AVs are considered in a social context, within which the problems and issues to be solved become the starting point for design at a fundamental level.

Practical Implications

The research carries significant implications for practice in that it advocates locating those socio-contextual issues at the heart of the problem definition and design process, and ahead of technical solutions.

Keywords

Urban design, Autonomous Vehicles, participation, co-design, people, case studies, planning

Introduction

> 'New technologies tend to expand what we can do, but do not necessarily indicate what we should do.'
>
> (Litman, 2019)

This paper draws on the experiences of the Interreg North Sea Region funded projects ART-forum (Automated Road Transport) and PAV (Planning for Autonomous Vehicles) which implemented five urban AV pilots (in Aalborg, Almere, Hannover, Inverness and Varberg). It proposes that we should explore and draw on the potential insights which may be gained through designing AV initiatives using stakeholder participation as a core methodology.

The research was cognisant of the fact that the problem(s) to which AVs present a solution are likely to be affected by the situation, background, goals and wider context of stakeholders. It is also vital to appreciate that the lens through which individual or groups of stakeholders view the world will deeply affect the perceived usefulness and likely impact of any new technology. As noted by Robinson *et al.* (2021), who explored the use of lensing within policy making, the "worlds" of scenarios can be presented and understood in terms of perspectives which then require further elaboration and interpretation. For example, key stakeholder groups affected by AVs are diverse, and the "problem" to which AVs may present a potential solution will vary between cases:

- Vehicle manufactures (need for additional revenue)
- Drivers/passengers (comfort, safety)
- Mass transit companies (replacement or redeployment of human resource)
- City authorities (desire for smart transport planning)
- Pedestrians (safety)

Therefore, the central research path concerned how stakeholder engagement can help to ensure the realisation of cities which are socially sustainable, and where new and emerging technologies such as autonomous vehicles can work in service of that goal.

Contextual Background

Throughout urban planning history, newer transportation systems have repeatedly cast aside and oppressed older travel methods. For instance, during the 20th Century, cars dominated roads as the sole method of transport, as dictated by modernist urban planning ideals, thus marginalising cycling and walking (Gaio and Cugurullo, 2022).

It is important to note the political background against which these shifts in planning ideology took place. Automobile domination was the result of car manufacturers' government lobbying during the 20th Century. Convincing politicians that cycling and walking are a danger to people's lives due to the presence of cars has resulted in the oppression of these active travel methods (Gaio and Cugurullo, 2022). As a result, automobiles became the only so-called "safe" form of transport available, one that "is neither socially necessary nor inevitable but has seemed impossible to break from" (Urry cited in Cugurullo and Gaio, 2022).

Thus, the introduction of cars was largely imposed, with no stakeholder consultation. In fact, citizens often protested the construction of motorways and/or the domination of automobiles. For instance, the Netherlands' famous adoption of cycling as a mainstream form of transport originated from a

social campaign concerned about children's safety; it highlighted the number of children killed every year by motorists (Gaio and Cugurullo, 2022). It is worth noting that the Netherlands did not have car manufacturers to lobby against the development of cycling infrastructure.

However, in most parts of the world, the shift towards cars caused significant social, economic, environmental, and urban challenges that cities face today. For instance, increased access to cars as a quick transportation method allowed people to live farther away from their places of work (which is mostly in cities), thus contributing to urban sprawl (Gavanas, 2019).

Perhaps, however, one of the most notable negative impacts of car-centric planning is the disintegration of walkable cities and with it the lack of social interaction and placemaking, qualities of which Jacobs (2011) and Gehl (2011) have long observed their decline and thus advocated for. For instance, Jacobs (2011) observes in her book *The Death and Life of Great American Cities* that attempts to predict, shape, or control people's behaviour through urban design ends in failure, with the result being cities that promote social alienation, lack of security, lack of social interaction, and lack of life. Her views were later confirmed through Gehl's (2011) public life studies on urban planning. In a more recent study, the work of Lotfata *et al.* (2022) serves to draw attention to the changes, pressures and potential of urban walking in the context and aftermath of the COVID-19 pandemic, and to place the importance of mobility in a social, health and economic context.

Therefore, it can be said that the widespread use of private cars, urban sprawl, and inefficient and unequal use of space in cities have hugely contributed to undesired spatial ramifications and to a general poor state of society's health (for example as discussed by Rojas-Rueda and Turner, 2016). These issues, in addition to environmental sustainability, paint the broad strokes of what current problems cities face today as the result of the machine city ideology. They therefore need to be accounted for and placed at the forefront of discussion when considering implementing a new technology such as autonomous vehicles, which has the potential power to exacerbate these detrimental effects on people's health and wellbeing.

Current AV Research

> 'It [AVs] is a disruptive technology that has the possibility of bringing positive as well as negative outcomes to stakeholders.'
>
> (Strömberg *et al.*, 2021, p.9)

Studies predicting the future of autonomous vehicles vary greatly, ranging from the hopeful and optimistic to the more careful and critical. This is because sufficient data needed to assess whether autonomous vehicles will exacerbate current planning problems or resolve them is lacking (Gavanas 2019), and current hypotheses often seem contradictory. For example, one argument for AVs claims that they will reduce the number of cars on the road. This can be achieved by incorporating them with planning concepts such as transit-oriented development (TOD) whereby high-density areas are located near public transport systems. In this scenario, AVs can assist with TODs by connecting people who live farther away with public transport networks, thereby helping people cover the 'last mile' of their destinations (Duarte and Ratti, 2018). This hybrid solution would in turn help reduce cars on the road and increase public transport uptake. Still, AVs can never truly replace public transport in terms of sustainability, capacity, and efficiency since the latter is a denser form of transport that occupies less road space.

In addition, AVs can be used in ridesharing schemes, also decreasing cars on roads. However, the answer is not simple nor straightforward. For instance, AVs can exacerbate urban sprawl as they would alleviate the stress and exhaustion caused by driving. This can provide an incentive for people to live farther away from cities as commuting becomes more enjoyable and efficient (Duarte and Ratti, 2018), thereby increasing the number of cars.

Another potential benefit to AV adoption is the freeing of parking spaces. In a scenario where AVs are moving 70% of their time (as opposed to 5% of the time with motor vehicles), constantly picking up and dropping off users, AVs can free parking spaces within cities (Duarte and Ratti, 2018). This can mean more public space availability. It can also mean less on-street parking, leading to smaller streets and therefore denser and more compact cities.

Finally, in the same way that 20thC cars oppressed active travel methods, there is a well-founded concern that autonomous vehicles will oppress them again, specifically cycling, a much-needed method of sustainable transport in cities. This will give commuters less transportation choice and will be in direct opposition to current planning's sustainable and social goals where cycling provides a cheap, environmentally friendly alternative to driving (Gaio and Cugurullo, 2022). Other vulnerable road users will potentially be impacted by the encroachment of autonomous vehicles as well: pedestrians and those who use wheelchairs, skateboards, or other micro-mobility methods.

In that respect, AVs could be seen as potentially the most innovative and promising (Fagnant and Kockelman, 2015), yet the most disruptive intervention that would profoundly remodel our cities and socio-spatial organisation in terms of land planning and use (Legacy 2019; Yigitcanlar *et al.*, 2019). While some studies have considered the politics of sustainability transitions (Avelino *et al.*, 2016; Chatterton, 2016) and others have explored the political implications of low-carbon transitions in building standards (Affolderbach & Schulz, 2016) and energy (Bouzarovski & Simcock, 2017; Petrova, 2018), research on mobility transitions more often focuses on technological change as the starting point of inquiry. Technologically driven sustainable mobility solutions (such as electric bicycles and delivery drones) are abundant; however, transport scholars agree that focusing on technology alone is insufficient and can be counter-productive (Banister *et al.*, 2013; Ferreira *et al.*, 2017). Little, if any, attention has been paid to parallel theorisations of mobility transitions originating from a concern for social justice. In fact, scholars of environmental justice and just sustainability have long argued that a singular focus on carbon emissions may lead to a new world of mobility that fails to address structural asymmetries of power (Chatterton, 2016; Swilling & Annecke, 2012). Chatterton (2016, p. 403) observes that "there remains a reluctance to name and advocate for the more radical nature of transitions that society needs to embark on to address the huge challenges it faces". In the same vein, narrowly framing AV issues on technological benefits or legislative matters to accelerate AV introduction conceals the multitude of social issues integral to AV implementation, such as the contemplation of alternative mobility scenarios; the interrelationships between people, vehicles, and real/perceived scenarios; and the consequences of those relationships.

Scholars believe stakeholder engagement can play a key role in bridging this gap. For instance, Shibayama *et al.* (2019) highlighted that a collaborative approach among all stakeholders, including governments, citizens, companies, and planners, is a key step for AV deployment to complement sustainable mobility goals. However, there is a lack of research comparing different stakeholders' points of view and assumptions about autonomous vehicles despite this comparison being crucial for the successful implementation of AVs (Strömberg *et al.,* 2021). This includes engagement with active travellers such as cyclists (Gaio and Cugurullo, 2022), whose input is needed to avoid another wave of active travel oppression.

It is therefore argued that public engagement activities and research in social science could play an active role in recommending alternative routes to achieve sustainable future mobilities, determining the success of AV technology, and contributing to imperative discussions about social justice. As Graham, 2010 (quoted in Cohen *et al.*, 2020) highlights, '*We should not wait for an AV-related infrastructural disaster*.'

Research on driverless vehicles is relatively well developed within the technological field, while social science research on the likes of users' experiences with driverless vehicles and the societal opportunities and risks of the technology are limited (Heikoop *et al.*, 2020; Yeo and Lin, 2020a). Existing studies that investigate user perspectives often focus on 'user acceptance' (see Nordhoff *et al.*, 2017). Several studies find that among potential users there is an overall positive attitude towards driverless vehicles (e.g. Mouratidis and Cobeña Serrano, 2021; Nordhoff *et al.,* 2018; Rehrl and Zankl, 2018; Salonen and Haavisto, 2019), but it is also emphasized that "[…] *a positive attitude does not imply that people will be willing to adopt them*"(Roche-Cerasi 2019, p. 172).

The specific and often quantified focus on the positive and negative experiences of driverless technology may indicate broad support for driverless vehicles, but it often remains unclear in these studies what nuances exist in informants' answers and what factors are actually measured. For example, studies have found that users' 'positive attitude' to driverless vehicles may be due to the anticipation of what these technologies will be able to contribute in the future (López-Lambas and Alonso, 2019), not least because only a very few have actual experience with the technology.

There is also a potential discrepancy between users' ideas about, enthusiasm for and expectations of driverless vehicles and the real technological development and limitations that the vehicles have (Nordhoff *et al.*, 2017; 2019; Mouratidis and Cobeña Serrano, 2021). Studies point out, for example, that despite a positive attitude towards driverless shuttles, several informants do not find them practical in their current form (Roche-Cerasi, 2019; Mouratidis and Cobeña Serrano, 2021; Nordhoff *et al.,* 2019). Finally, the research in the area has also faced criticism for being based on an assumption that technological breakthroughs unilaterally determine people's reality, with people reduced to passive recipients of driverless technology (Yeo and Lin, 2020a).

The Case for Stakeholder Engagement and a Human-centred Approach

> 'The question is not when AVs will arrive or how to accelerate that arrival. Instead, we should be asking where the technology would be appropriate, who is likely to benefit, who the stakeholders are, what form it could take and what ends should be prioritised.'
>
> Tennant and Stilgoe (2021)

The questions oscillating around AVs need to be re-framed so that the focus shifts from technological advancement to understanding and addressing the problems and challenges people face. This can occur by 'putting technology "in its place" in terms of understanding and respecting the contexts in which it might be deployed,' (Cohen *et al.,* 2020, p. 2). When focusing on urban planning issues, this shift of perspective towards a human-centred approach can provide research context that addresses how AVs may be an innovative mobility 'solution' whilst drawing on social science and collaboration.

In that regard, the gradual introduction of autonomous vehicles into existing built environments could potentially be seen as an opportunity for a fundamental rethink of detrimental aspects of the current relations between urban spatial planning and transportation systems, facilitating sustainable mobility and complementing active travel. However, innovation such as that potentially emerging through automated transport cannot be led as a monologue, and AVs should not be seen as an all-encompassing solution before identifying the often complex urban problems which they could address or ameliorate.

However, and often in advance of necessary ongoing public debate and engagement being established, autonomous vehicles are being developed and tested not only in private laboratories but also on public roads, often in complex mixed mobility scenarios (Arvin *et al.* 2021, Pereira *et al.* 2019). Thus, it can be argued that postponing the questions and scrutiny into the purposes and consequences of this potentially disruptive technology is somewhat foolhardy.

Furthermore, the urban systems including all road structures intermeshed with the AV worlds could become an enormous digital depository of tangible personal data having an immediate and immense impact on security, privacy, and freedom. The future algorithms and data politics (ownership, bias, sharing and use of information) could become an important aspect of understanding the accountability in crash/crime/safety investigations (Winfield and Jirotka, 2018; Stilgoe, 2018) as well as exposing the fragility of the systems' benefits.

Finally, a spectrum of feelings may be associated with introducing such novel technology as self-driving vehicles on the roads, from excitement and enthusiasm to the uncomfortable sensation of dooming, inevitability, and thus helplessness (Martines Diaz *et al.,* 2018; Wolf, 2016). The reality is very much nuanced when it comes to assimilating new [potentially highly disruptive] technology, and arguably, what may be required is a notion of humbleness about predicting the future as well as identifying its limits without succumbing to the seductive quality of technology (Mindell, 2015) and the hype around it. The apprehension associated with the new technology and the moral dilemmas of security and privacy potentially leading to a *'[d]ystopic digital Orwell-ization of self and society'* (Urry, 2007, p.276) need to be considered with broad issues of ethics and safety; people [in human-machine interactions] have always been active agents and should be categorised as more than just consumers whose lives can simply fall under 'datafication' of everyday life to create their user profiles.

To demonstrate the importance of stakeholder engagement in the AV discussion, a study conducted by Strömberg *et al.* (2021) revealed and compared urban planners, future users, and AI developers' hopes and concerns regarding AV deployment. The three groups shared the same hope, namely for AVs to become a more sustainable transport method and to provide their users with more services. However, they also agreed that the dispersal of AVs would conflict with urban sustainability goals such as reducing carbon emissions and car dependence.

Beyond that, the groups had different views when it came to the technology's implementation. For instance, urban planners and developers predicted changes in travel demand, where there would be fewer cars on the road. This, on the other hand, was not entirely found among future users, with opinions ranging from a reduction in demand due to ride-sharing options to the increase of "chaos" in city centres (Strömberg *et al.*, 2021).

In addition, developers hoped that AVs could save municipalities infrastructural investments by using existing roads to their full capacity rather than investing in train infrastructure. However, urban planners pointed the need for major infrastructural changes to accommodate AVs, with one claiming that it wouldn't be cheap (Strömberg *et al.,* 2021).

Interestingly, future users were the only group to highlight inclusivity and social justice. They discussed potential job losses resulting from AV implementation and discussed the need for a robust system (i.e., software that does not freeze or cause mishaps) to allow those who cannot drive, such as wheelchair users, to ride AVs safely. They also brought a more humanistic perspective to the discussion, imagining how people would feel inside autonomous vehicles and how they can be rescued in the event of an accident. They had a heartfelt concern that allowing technology to dictate the future blindly would oppress societal values such as equality and sustainability. They also highlighted concerns regarding the lack of an authority figure in vehicles for safety, a role currently understood to be undertaken by bus drivers (Strömberg *et al.,* 2021).

In addition, they expressed concerns that AVs would become too attractive to users, eventually becoming the one preferred transport method over cycling or walking (active travel), a view like the one argued by Cugurullo and Gaio (2022).

Finally, future users questioned the motives behind AV development, with one stating "is it about money, or about the environment, or many of the other aspects? What is the main purpose of it?" Interestingly, developers shared the same questions. "… in the grand scenario, what is the role of the AV?" and so did urban planners "What do we want? What should we work for?" (Strömberg *et al.*, 2021, p. 8).

In conclusion, the groups agreed on the complexity of AV planning and had similar hopes for their positive implementation; however, they differed in how this implementation needs to take place and had different concerns regarding their negative consequences. Future users brought the human factor to the AV implementation issue. Where planners spoke from an urban perspective and developers spoke from a technological one, future users brought to the table more human-centric issues such as people's interactions with and feelings towards autonomous vehicles, inclusivity, job losses, and active travel oppression, among other societal values. As a result, future users were more concerned about the social implications of AVs, something that other stakeholders did not dwell on or explicitly mention. It has been highlighted through other studies that stakeholder engagement is necessary to uphold these societal values.

Self-driving Cars as an Open-ended Social Experiment

> 'If technological issues continue to dominate the research effort, questions of huge societal importance will be either missed or dealt with superficially.'
>
> (Cohen *et al.* 2020)

AVs will be 'attached' (Stilgoe, 2020) and connected in many ways to the world around them and will have profound cultural and social consequences (on top of spatial, infrastructural, legal, and environmental issues). Stilgoe (2020) explicates that attachments can be defined as commitments, relationships with people, objects, institutions, and infrastructures - the crucial points where the technology would meet the 'real world'. When attachments are not considered or omitted on purpose and certain technology assertions go unquestioned, the world and the cities we live in may be pressured to adapt to AVs rather than the other way around. 'Expressions of desire to re-engineer the world for the sake of AVs are common among developers' (…, p.151), demanding spatial and infrastructural changes and forcing people to behave in more 'predictable' ways to accommodate technology. This 'mechanistic' point of view is similar to the one commonly held during the 20th century following the introduction of motor vehicles; cities were seen as 'a territory

to be bounded, mapped, occupied, and exploited, [and] a population to be managed and perfected,' (Donald, cited in Robbins, 1998).

Conversely, acknowledging the aforementioned would lay foundations for a more inclusive establishment of AVs, one that makes the introduction of the technology a means to societal goals (safety, sustainability, improved urban environment, accessible mobility, and mobility justice) rather than an end in itself. It can be said that AVs and 'the places and lifestyles that are created around them represent an open-ended social experiment that urgently needs to be democratised' (Stilgoe, 2020).

Furthermore, Stilgoe (2020) explains how the obsolete 20th century mechanistic view can repeat itself: whereas motor vehicles mandated traffic lights, jaywalking laws, and car parks, autonomous vehicles could introduce dedicated lanes, new pedestrian rules, smart infrastructure, and digital high-definition maps. He further highlights that '[*t*]*he story currently being told by self-driving car developers downplays these aspects. The car, we are told, will be smart so that the world around it does not have to be; artificial intelligence will do everything a human driver can do and more. This "myth of autonomy" will, if swallowed whole, lead to some bad decisions.*' (Stilgoe, 2020). In addition, there are myriad ways in which the promise of autonomy could turn into a set of demands and a 'self-fulfilling prophecy' (Van Lente and Bakker, 2010). As the claims surrounding new technologies start to be believed in, adjustments would naturally happen.

Thus, this technologically deterministic view should be confronted as it often oversimplifies and superficially translates the problem—mainly human error into the simple solution—the initiation of ultra-aware artificial intelligence. This needs to be coupled with resisting the 'hype' around AVs, targeting the needs of those who often lose out from innovation, and enabling new collaboration to flourish.

As noted by Legacy *et al.* (2019, p. 91), 'the emergence of AV technology and the drive from the IT and automobile industry falls squarely into the area of corporate storytelling and should arguably therefore be subject to further critical discourse across the urban planning and transport planning literatures.' In this vein, we recognise the importance of scrutinising technologies at an early stage before they become commonplace. The narrative built around AVs must not be asymmetrical and mainly derived from commercially driven aspects of technology or interests that would not necessarily accord with public interests. In fact, Strömberg *et al.* (2021) appear in sharp contrast with what the media and tech companies circulate about AVs. Interestingly, this gap between reality and media hype was a concern that developers highlighted during their discussions.

For instance, WSP and Farrells asserted that "*driverless and autonomous vehicles are coming, and they will be transformational,*" (as cited in Skinner and Bidwell, 2016, p. 4). They proposed the concept of an "AV zone" within the city, an area where pedestrians and cyclists share space with AVs without motor vehicles. It asserts that such a scenario is safe and prioritises people and cyclists over cars, highlighting that roads will be shared among all three (Skinner and Bidwell, 2016). However, AV developers from Strömberg *et al.* (2021)'s study have expressed their concerns regarding over trust in the technology as well as the challenges of integrating AVs in shared space scenarios such as this one. In fact, during scenario-building, an engineer in object detection, radar sensors, and neural networks has suggested an AV-only zone, with "no motorcycles, no manually operated cars, not even bicycles" as the easier way to implement AVs. Cugurollo and Gaio (2022) have also highlighted artificial intelligence's weaknesses in identifying cyclists. Thus, 'as human behaviour is oftentimes unpredictable and far from being automated, driverless transport modes will somewhat have to acquire 'additional social intelligence' (Camara *et al.,* 2020, p. 1) to function in complex socio-spatial environments. This consequently confirms their concerns about a 3rd wave of oppression for cyclists and other vulnerable road users.

Finally, incorporating new technologies is not always the answer. In fact, the opposite is sometimes true. In 2017, traffic lights were removed from a busy intersection in Amsterdam to reduce the number of people who disobey traffic signals (Gaio and Cugurullo, 2022). The result was successful and is an example of removing technology as a solution as opposed to adding it. This demonstrates the dangers of implementing technology for technology's sake, where people are forced to adapt themselves to technology rather than developing it to adapt to their needs (Gaio and Cugurullo, 2022) as tech corporations often advocate (Stilgoe, 2020). This is why new transport solutions need to be 'socially progressive rather than reinforcing already entrenched inequalities and repressive ideologies,' (Bissell *et al.,* 2020, p.128). This can be achieved by thinking about autonomous futures in new ways that integrate public consultation in every implementation stage (Bissell *et al.,* 2020).

Approaches Adopted for Stakeholder Engagement

As part of the PAV project activities, each of the pilot representatives was encouraged to implement open, regular and longitudinal public engagement events as forming the AV implementation journey.

It can be argued that to achieve success, the involvement of representatives from across the relevant societies who might be affected by AVs and later planned projects should be ensured; stakeholders should not be limited to expert groups or those in positions of power (decision makers only) the same way the narrative built around AVs should not be based on technologically-mingled and commercial aspects only. The intention underlying the engagement activities is also to establish and then implement a process through which a group of stakeholders, selected in response to the demands and aspirations of each pilot study, are able to provide guidance and feedback to each of the local project teams, whilst also engaging in activities throughout the planned work, and extending from the design stage through to the delivery, monitoring and evaluation of projects on site. Qualitative methods need to be designed (customized) to identify and analyse (some of the) "*unfolding relations between technology and society, spaces where human agency may be found despite the structural grammar set by automation*." (Yeo & Lin 2020, p. 5).

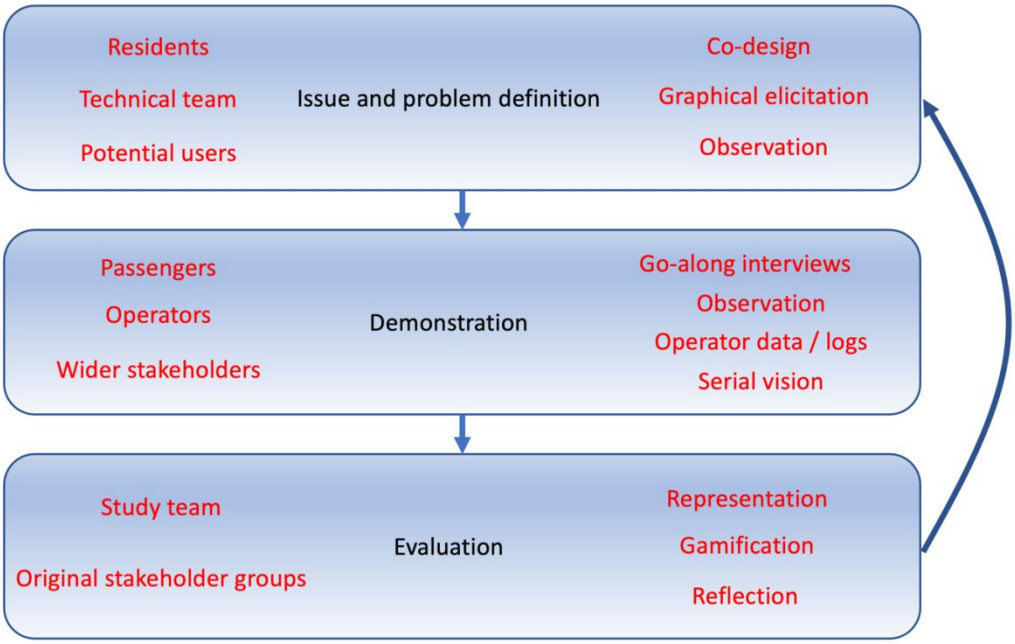

Figure 1: suggested longitudinal approach to AVs and stakeholder engagement

Studies from around the world have revealed that there are important unresolved questions about where, how and with what benefits the technology can be used. For example, in Aalborg East, the Smartbus trial was set up to investigate the technology as a means of pursuing practical and social purposes in a concrete urban context and as part of the ongoing social transformation of an existing urban area. In line with this broad intention, the task description for Aalborg University's study was not bound by special hypotheses or fixed boundaries in relation to what knowledge the study specifically could or should produce. Because the use of driverless technology is a new field, it has been a research goal in itself to collect the richest and most nuanced material possible about the concrete encounters between technology, city and people, herein insights into the route's specific spatial characteristics and design, the ways the shuttles were used and who used them, and the narratives about place and identity in which the shuttles were embedded.

The Aalborg study of how the driverless shuttles and the transformation of Astrupstien affected life on and around the path took place over a number of years, from the initial studies in 2017 to the end of the project in 2021. Throughout this period, the shuttles gave rise to interviews, informal conversations, workshops and observations about driverless technology, the district's qualities and challenges, and the path's many uses.

The study of these concrete encounters between technology, city and people demonstrates, among other results, that the trial brought about new narratives in and about the district of Aalborg East. The users of the path generally embraced the shuttles, although there were also some who found them disruptive to the general flow of the path. There was initially a concern among some residents that vandalism would be committed on the shuttles or that the artwork in the tunnel and on the shuttles' garage would be destroyed. Many ultimately reported finding it positive and uplifting that the furnishings and decoration were allowed to remain undisturbed. Several expressed their view of the Smartbus project as a positive contribution to the district's development because it meant that Aalborg East was associated with innovation and solutions for the future rather than social problems or vandalism. Others questioned whether the money would have been better spent on other initiatives in the district. All in all, the trial has added a new chapter to the compilation of narratives

about social problems and strong counter-narratives about unity, colour and diversity that exist in and around Aalborg East.

The study incites further curiosity as to the development of a community approach to driverless technology. The richness of the interactions that took place in and around the shuttles, between shuttle users, path users and operators, warrants continued curiosity about how driverless mobility can be brought into play as an element in sustainable mobility development and urban development. It is possible that the experience could be used to investigate whether a community approach to driverless technology can be further developed, one that integrates mobility, local community development, social work and the quality of public spaces to follow new model, e.g. in the form of a collaborative project where local actors, such as businesses, leisure facilities, transport companies, housing associations and nursing homes, join together in implementing a local citizen-oriented driverless service bus.

Case study Research and AVs

It may be argued that the urban realm is a highly contested area where many stakeholders, systems and agents have often conflicting demands and expectations. The infrastructural and thus built environment changes intrinsic to cities and their [re]development have had immense - occasionally unintended - social, cultural, and environmental implications (Tierney, 2017). As the technological advancement paralleled with mobility and societal progress turn toward the widespread adoption of AVs, a series of uncertain and once more unintended planning consequences might be expected (Pangbourne *et al.*, 2018). Furthermore, stakeholder engagement might offer a means of assessing mobility needs unbiased. As Servou *et al.* (2022) highlight, conducting urban experiments is often done based on preconceived notions that the subject of experimentation is positive, thereby leading to biased results. By involving stakeholders from different backgrounds while simultaneously bringing them together under one goal, namely sustainable mobility, different points of view, discussions, and solutions can be brought forth, thereby reducing absolutist, biased solutions.

Different urban contexts will require different solutions, which stakeholders can highlight and/or clarify. As Servou *et al.* (2022) indicate, scalable experiments are not always viable because it cannot be assumed that what works in one area will work in another. This is because the context is often different, thereby making a “one solution fits all” approach detrimental.

Research is often associated with the search for answers that are universally applicable across locations and social contexts and that are easily transferable to projects or applications elsewhere. In the study of people and society, however, this type of transferable knowledge has often been shown to be illusory. As one of the method’s proponents, Flyvbjerg (2010, p. 466), noted in an article concerning case studies, this is not because no attempts have been made: “*Despite persistent attempts to develop context-independent and predictive theory as in the natural sciences, in the social sciences you always end up with context-dependent knowledge*”.

A consequence of studying phenomena in their social and spatial context is that the descriptions that emerge can rarely be summed up unambiguously in a single unified argument. The case presentation consists of perspectives and experiences which are characterized by the complexity of lived life and people’s mutually contradictory perceptions. Our goal has been to highlight the co-existence of these different perspectives and the importance of considering all of them meaningfully when discussing AV development. Indeed, the matter itself is multi-faceted and complex, with many different factors coming into play.

It is suggested that future research should explore and apply findings in relation to the potential for AVs to extend the use of shared mobility (following work by Narayanan, 2020; Tian *et al.,* 2021), rather than to further increase the number of vehicles using road space, albeit though new technology. Likewise, the effects of context on the implementation of Avs will be critical, with the methods applied in the case of Aalborg suggested as a route towards establishing user and community needs. Coupled with this, the importance of having political and democratic processes capable of supporting and enabling such engaged design is critical (following, for example, the seminal work of Jensen 2011; and more recently that of Aoyama and Leon, 2021). Indeed, recent work (AlWaer *et al.,* 2021) described how such governance of democracy requires clear and shared follow-up planning, an agreed action programme and a delivery mechanism to ensure that aspirations are met.

Discussion and conclusions

This paper argues that the implementation of AVs first requires the contextualised application of co-design methods (following Sanders and Stappers, 2008; Yang *et al.,* 2021) used to help stimulate debate, facilitate understanding, and help to open a dialogue with potential end-users and to engage stakeholders early in the process of its development and regulatory deployment. As noted by Cohen *et al.* (2020*), 'the technology, if it is to succeed in its own terms, must work with and incorporate the social complexities of the real world*'.

However, the reality of many mobility interventions is that they do not take place within the holistic consideration of urban areas, wherein complex intersectional interactions between mobility, health, inclusivity, economics and suchlike can be addressed. The well-established importance of longitudinal evaluation of mobility interventions (as described by Mertens *et al.,* 2019) within a research context, is often difficult or even impossible to implement within the context of larger-scale projects. This may be due to disconnections between inception, procurement, initial application and running, in terms of budgets and parties involved. What is perhaps more troubling in the context of emerging technology of AVS, including their connectivity with wider urban systems, is that the great majority of applications and studies have taken the form of demonstration or pilot projects, where it is difficult to identify and engage with 'real' end users, let alone explore how the projects would cause change or be a disruptive force within urbanism.

Autonomous vehicles will have profound impacts on our quality of life, our streets and immediate neighbourhoods. The nature of the changes will largely depend on how and whether we respond to the challenges ahead and guide the questions we would ask as citizens, and professionals closely involved with developing or negating the technology. It is believed that the participation of users at the design stage carries the potential to greatly improve results and modal shift.

During the 20th Century, "*Cyclical transport mode oppressions were the result of the political agendas, histories of infrastructure, societal norms, technologies, energy access, and geopolitical alliances*," (Gaio and Cugurullo, 2022). Lobbying played a key role then, with auto-manufacturers advocating for various policies that are to their advantage. Today, the "politics [of AI] are driven by Great Houses of AI, which consist of the half-dozen or so companies that dominate large-scale planetary competition." (Crawford, 2021, cited in Gaio and Cugurullo, 2022, p.11). In fact, AV developers from Strömberg's study alluded that opposition to their companies' visions would get them labelled as "whistle-blowers". This is too similar of a situation to that of the 20th Century, with a concentrated few having the power to shift the political scene in their favour, yet again without

the engagement of other stakeholders, much to said stakeholders' detriment (Gaio and Cugurullo, 2022).

On the other hand, it is well-documented through Gehl (2011) and Jacobs (2011) that human-centric urban design contributes to liveable, thriving cities and is in line with sustainable mobility goals. AVs then can be a double-edged sword, where thoughtful implementation can complement the current shift towards active-travel, public transport, and 15-minute cities. Otherwise, it can perpetuate car-centric design, for "emphasizing technology first and incumbent dominant modes of transportation will result in similar outcomes to historical transport oppression," (Gaio and Cugurullo, 2022, p.8). A key way to avoid this is through stakeholder engagement and collaboration between academia, politicians (governments), users, and auto-manufacturers, with the shared goal of making cities more sustainable, liveable, and sociable. Empirical evidence and research need to inform policy-making and subsequent urban planning, and democratisation of the process plays a key role in averting a technocratic future. Otherwise, history is bound to repeat itself.

References

Affolderbach, J. and Schulz, C. (2016), "Mobile transitions: Exploring synergies for urban sustainability research", *Urban Studies*, Vol. 53 No.9, pp.1942–1957.

AlWaer, H., Rintoul, S. and Cooper, I. (2021), "An investigation into decision-making and delivery activities following design-led events in collaborative planning", *Archnet-IJAR*, Vol. 15 No. 3, pp. 752-773.

Aoyama, Y. and Alvarez Leon, L.F. (2021), "Urban governance and autonomous vehicles", *Cities*, Vol. 119 pp. 103410.

Avelino, F., Grin, J., Pel, B. and Jhagroe, S. (2016), "The politics of sustainability transitions", *Journal of Environmental Policy & Planning*, Vol. 18 No.5, pp.557-567.

Arvin, R., Khattak, A.J., Kamrani, M. and Rio-Torres, J. (2021), "Safety evaluation of connected and automated vehicles in mixed traffic with conventional vehicles at intersections", *Journal of Intelligent Transportation Systems*, Vol. 25 No.2, pp 170-187.

Banister, D. and Hickman, R. (2013), "Transport futures: Thinking the unthinkable", *Transport Policy*, Vol. 29, pp. 283-293.

Bouzarovski, S. and Simcock, N. (2017), "Spatializing energy justice", *Energy Policy*, Vol. 107, pp 640-648.

Camara, F., Bellotto, N., Cosar, S., Nathanael, D., Althoff, M., Wu, J., Fox, C. (2020), "Pedestrian models for autonomous driving Part I: low-level models, from sensing to tracking", *IEEE Transactions on Intelligent Transportation Systems*, https://arxiv.org/abs/2002.11669, pp. 6131-6151.

Chatterton, P. (2016), "Building transitions to post-capitalist urban commons", *Transactions of the Institute of British Geographers*, Vol. 41 No. 4, pp. 403-415.

Cohen, T., Jones, P. and Cavoli, C. (2017), "Social and behavioural questions associated with automated vehicles", Scoping study by UCL Transport Institute, Final report, London: Department for Transport.

Cohen, T., Stilgoe, J., Stares, S., Akyelken, N., Cavoli, C., Day, J., Dickinson, J., Vaike Fors, V., Hopkins, D., Lyons, G.,Marres, N., Newman, J., Reardon, L., Sipe, N., Tennant, C., Wadud, Z., Edward Wigley, E. (2020), "A constructive role for Social science in the development of automated vehicles", *Transportation Research Interdisciplinary Perspectives*, Vol 6, pp. 100133.

Cross, N. (1982), "Designerly Ways of Knowing: Design Discipline versus Design Science", *Design Issues*, Vol 17 No. 3, pp. 49-55.

Duarte, F. and Ratti, C. (2018), "The Impact of Autonomous Vehicles on Cities: A Review", *Journal of Urban Technology*, Vol. 25 No.4, pp. 3-18

Fagnant, D. and Kockelman, K. (2015), "Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations", *Transportation Research Part A: Policy and Practice*. Vol. 77, 10.1016/j.tra.2015.04.003.

Ferreira, J., Carvalho E, Ferreira BV, de Souza C, Suhara Y, Pentland A, Pessin. *G.* (2017), "Driver behavior profiling: An investigation with different smartphone sensors and machine learning", *PLoS ONE*, Vol. 12 No.4, e0174959.

Flyvbjerg, B. (2010), "Fem misforståelser om casestudiet (Five Misunderstandings about Case-Study Research)", in, Svend Brinkmann and Lene Tanggaard, eds., *Kvalitative metoder*, København: Hans Reitzels Forlag, pp. 463–487,

Gaio, A. And Cugurullo, F. (2022), "Cyclists and Autonomous Vehicles at Odds", *Ai and Society, Vol.* **38**, pp. 1223–1237.

Gavanas, N. (2019), "Autonomous Road Vehicles: Challenges for Urban Planning in European Cities. *Urban Science, Vol.* 3, No.2.

Gehl, J. (2011), *Life Between Buildings: Using Public Space,* London: Island Press.

Jacobs, J. (2011), *The Death and Life of Great American Cities.* 4th ed. New York: Random House Publishing.

Jafarnaimi, N. (2018) "Our Bodies in the Trolley's Path, or Why Self-driving Cars Must *Not* Be Programmed to Kill", *Science, Technology, & Human Values*, Vol. 43 No.2, pp. 302-323.

Jensen, A. (2011), "Mobility, Space and Power: On the Multiplicities of Seeing Mobility", *Mobilities*, Vol. 6 No.2, pp255-271.

Lawson, B. (1980), *How designers think*, Taylor and Francis.

Legacy, C., Ashmore, D., Scheurer, J., Stone, J., Carey Curtis, C. (2019), "Planning the driverless city", *Transport Reviews*, Vol. 39 No. 1, pp. 84-102.

Litman, T. (2019), "The Future Is Not What it Used to Be: Changing Travel Demands and their Implications for Transport Planning", Plan Canada (https://bit.ly/2zGcgSi).

Martínez-Díaz, M. and F. Soriguera (2018), "Autonomous vehicles: theoretical and practical challenges", *Transportation Research Procedia*, Vol.33, pp. 275-282.

Mertens, L., Van Dyck, D., Deforche, B., De Bourdeaudhuij, I., Brondeel, R., Van Cauwenberg, J. (2019), "Individual, social, and physical environmental factors related to changes in walking and cycling for transport among older adults: A longitudinal study', *Health & Place*, Vol. 55, pp. 120-127.

Lotfata, A., Gemci, A.G. and Ferah, B. (2022), "The changing context of walking behavior: coping with the COVID-19 Pandemic in urban neighborhoods", *Archnet-IJAR*, Vol. 16 No. 3, pp. 495-516.

Mindell D. (2015) *Our Robots, Ourselves: Robotics and the Myths of Autonomy*. New York: Viking.

Mouratidis, K. and Serrano, V. (2021), "Autonomous buses: Intentions to use, passenger experiences, and suggestions for improvement", Tra*nsportation Research Part F: Traffic Psychology and Behaviour*. Vol. 76, pp. 321-335.

Narayanan, S., Chaniotakis, E. and Antoniou, C. (2020), "Shared autonomous vehicle services: A comprehensive review", *Transportation Research Part C: Emerging Technologies*, Vol. 111, pp. 255-293.

Nordhoff, S., van Arem, B., Merat, N., Madigan, R., Ruhrort, L., Knie, A. and Happee, R. (2017), "User Acceptance of Driverless Shuttles Running in an Open and Mixed Traffic Environ- ment." In 12th *ITS European Congress*. Strasbourg: ITS Beyong Borders. https:// www.researchgate. net/publication/317497564_User_Acceptance_of_Driverless_Shuttles_ Running_in_an_Open_and_ Mixed_Traffic_Environment.

Nordhoff, S., De Winter, J., Kyriakidis, M., Van Arem, B. and Happee, R. (2018), "Ac-ceptance of Driverless Vehicles: Results from a Large Cross-National Questionnaire Study", *Journal of Advanced Transportation,* 2018 (April). https://doi.org/10.1155/2018/5382192.

Nordhoff, S., De Winter, J., Payre, W., Van Arem, B., & Happee, R. (2019), "What impressions do users have after a ride in an automated shuttle? An interview study", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 63, pp. 252–269.

Pangbourne, K., Stead, D., Mladenović, M. and D. Milakis (2018), "The case of mobility as a service: a critical reflection on challenges for urban transport and mobility governance", in: Marsden, Greg, Reardon, Louise (Eds.), *Governance of the Smart Mobility Transition*. Emerald Publishing Limited, Bingley, pp. 33–48.

Pereira, J., Premebida, C., Asvadi, A., Cannata, F., Garrote, L. and Nunes, U.J. (2019), "Test and Evaluation of Connected and Autonomous Vehicles in Real-world Scenarios", in proceedings of *2019 IEEE Intelligent Vehicles Symposium (IV)*, Paris, France, 2019, pp. 14-19.

Petrova-Antonova, D., and Ilieva, S. (2018) "Smart Cities Evaluation – A Survey of Performance and Sustainability Indicators," *2018 44th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*, Prague, Czech Republic, 2018, pp. 486-493, doi: 10.1109/SEAA.2018.00084.

Planning for Autonomous Vehicles (PAV). Interreg North Sea Region Programme. (2020). [online] Available from:https://northsearegion.eu/pav/about/ [Accessed: 27 of January 2021]

Rehrl, K., and Zankl, C. (2018), "Digibus©: Results from the First Self-Driving Shuttle Trial on a Public Road in Austria", *European Transport Research Review*, Vol. 10 No.2.

Robinson,D.K.R, Schoen, A., Larédo, P., Molas Gallart, J., Warnke, P., Kuhlmann, S. and Ordóñez-Matamoros, G. (2021), "Policy lensing of future-oriented strategic intelligence: An experiment connecting foresight with decision making contexts", *Technological Forecasting and Social Change*, Vol. 169, pp. 120803.

Roche-Cerasi, I. (2019), "Public acceptance of driverless shuttles in Norway", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 66, pp. 162–183.

Rojas-Rueda, D. and Turner, M. (2016), "Diesel, cars and public health", *Epidemiology*, Vol 27 No. 2, pp. 159-162.

Rowe, G. and Frewer, L.J. (2005), "A typology of public engagement mechanisms", *Science, Technology and Human Values*, Vol. 30 No.2, pp. 251-290.

Salonen, A. O., & Haavisto, N. (2019), "Towards autonomous transportation. Passengers' experiences, perceptions and feelings in a driverless shuttle bus in Finland", *Sustainability*, Vol. 11 No.3, pp. 251-290.

Sanders E.B.-N., and Stappers, P.J. (2008), "Co-creation and the new landscapes of design", *CoDesign*, Vol. 4 No.1, pp.5-18.

Servou, E., Mögele, M., And Torrens, J. (2022), "Experimenting with automated driving for technology or for the city? A matter of governance cultures", *Frontiers in Sustainable Cities*, Vol 4, pp.956853.

Shibayama, T. Pungillo, G., Lemmerer, H., Nocera, S. *(*2019), 'Stakeholder involvement in decision-making process: a test assessment towards transition to autonomous vehicles", *Transportation Research Procedia*, Vol. 48, pp. 2550-2568

Skinner, R., Bidwell, N. (2016) Making better places: Autonomous vehicles and future opportunities, WSP Parsons Brinckerhoff and Farrells. Available from: https://www.wsp.com/en-gb/insights/autonomous-vehicles

Staricco, L., Brovarone, E., Scudellari, J. (2020), "Back from the future. A backcasting on autonomous vehicles in the real city", *TeMA - Journal of Land Use, Mobility and Environment*, Vol 13, pp. 209-228.

Stilgoe, J. (2020), "How to resist self-driving car hype", *Driverless Futures?*, online, https://driverless-futures.com/2020/05/20/how-to-resist-self-driving-car-hype/ [retrieved 8th March 2023]

Strömberg, H. Silva Ramos, É.M., Karlsson, M., Johansson, M., Ekman, F., Bligård L.O. and Bergstad, C.J. (2021), "A future without drivers? Comparing users', urban planners' and developers' assumptions, hopes, and concerns about autonomous vehicles', *European Transport Research Review*, Vol 13, paper 44.

Swilling, M., & Annecke, E. (2012), *Just transitions: Explorations of sustainability in an unfair world*. Cape Town: UCT Press & United Nations University Press.

Tennant, C. and Stilgoe, J. (2021), "The attachments of 'autonomous' vehicles", *Social Studies of Science*, Vol. 51 No. 6.

Tian, Z., Feng, T., Timmermans, H.J.P and Yao, B. (2021), "Using autonomous vehicles or shared cars? Results of a stated choice experiment', *Transportation Research Part C: Emerging Technologies*, Vol. 128, pp. 103117,

Tierney, T. F. (2017), *Intelligent Infrastructure: Zip Cars, Invisible Networks, and Urban Transformation*. Virginia: University of Virginia Press

Urry, J. 2007. *Mobilities*. Cambridge: Polity Press.

WHO. (2018). *Global status report on road safety 2018*. [online] Available from:https://www.who.int/publications/i/item/9789241565684 [Accessed: 9 April 2021].

Winfield, A. and Jirotka, M. (2018), "Ethical governance is essential to building trust in robotics and artificial intelligence systems", *Philosophical Transactions of the Royal Society A.,* Vol. 376, pp. 20180085 – 20180085.

Wolf, I. (2016), "The Interaction Between Humans and Autonomous Agents", in, M. Mauer, J. C. Gerdes, B. Lenz, H. Winner, eds. *Autonomous Driving. Technical, Legal and Social Aspects*. Springer Open. pp. 103-124.

Yang, L. and Zhang, L., Philippopoulos-Mihalopoulos, A., Chappin, E. (2021), "Integrating agent-based modeling, serious gaming, and co-design for planning transport infrastructure and public spaces", *Urban Design International,* Volume **26**, pp. 67–81.

Yeo, S. J. I., Lin, W. (2020), "Autonomous vehicles, human agency and the potential of urban life", *Geography Compass*, Vol. 14 No. 10, pp.1–12.

Yigitcanlar, T., Wilson, M., Kamruzzaman, M. (2019), "Disruptive impacts of automated driving systems on the built environment and land use: An urban planner's perspective", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 5 No.2.