LSE Cities Briefing Papers

Hybrid Cities Briefing Paper 2: Public Space, Connected People and Autonomous Systems

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1 Introduction

As digital connectivity and autonomous systems become increasingly pervasive in the public spaces and streets of our cities, reassessing the relationships between people's interactions, their behaviours, moving artifacts and public urban environments will become an increasingly necessary part of future city development. Critically analysing these relationships will assist proactive responses to future sociability needs, safety concerns and urban inclusion demands associated with the public realm of cities. Since its conceptualisation, research on hybrid-urban space has been concerned with the shift from desktops to handheld devices and the mobile digital-physical interactions of pedestrians (de Souza e Silva, 2006). Utilising the Hybrid Cities Lab's approach[i] to urban hybridity, we have constructed an ecosystem of inquiry, depicted in Figure 1, around the nexus of public city space, virtually connected people and autonomous systems that we share space with. Various types of hybrid activities undertaken by people on a daily basis are tied to autonomous transport in urban mobility systems and augmented reality (AR) technologies that are becoming increasingly popular. This review will use three nexuses of inquiry, depicted in Figure 2, to analyse the interactions within the larger ecosystem.

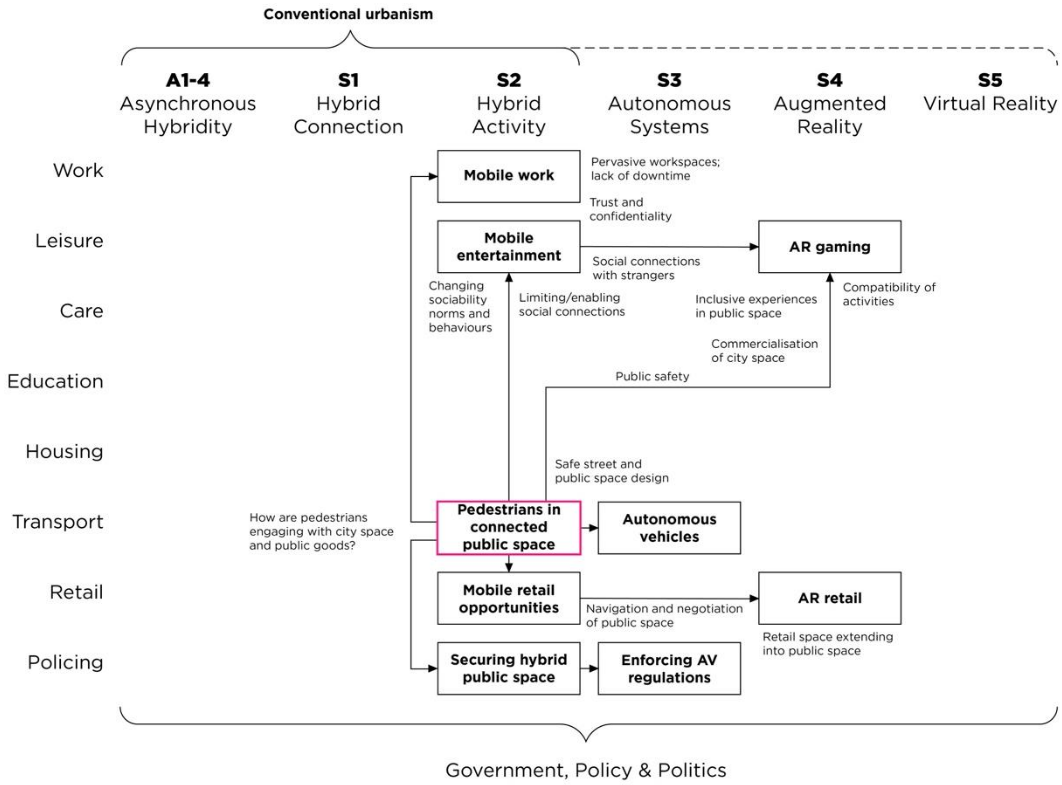

Figure 1. Public space, connected people and autonomous systems ecosystem.

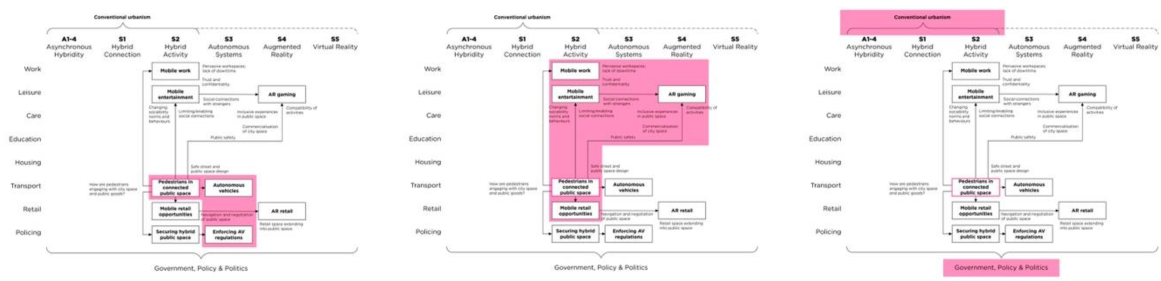

Figure 2. Three nexuses: (A) People and autonomous vehicle interaction; (B) People, devices and data; and (C) Public space and street design.

2 Nexus A: People and autonomous vehicle interaction

Autonomous vehicle (AV) services are estimated to be widely available to the urban public within a decade. Pilot projects in diverse cities including San Francisco, London, Singapore and Wuhan, have completed safety trials with driverless cars and robotaxis (ServCity, 2023, White, 2024). However, many cities worldwide remain far from even limited integration of autonomous vehicles into their transport ecosystems. Sharing road space with non-autonomous vehicles, motorists, cyclists and pedestrians presents many safety risks, prompting further research into pedestrian-AV interaction. This interaction is increasingly taking place via external human-machine interfaces, which enable simple and explicit communication between pedestrians and AVs (Zhanguzhinova et al., 2023) and lead to a greater acceptance of, and response to, AVs (Bellet et al., 2022). Wearable AR presents another way to reduce pedestrians' cognitive load when interacting with AVs on the road (Tran et al., 2022). Inside the vehicle, researchers have been studying the effective adoption of technologies such as AR head-up displays to improve road safety overall (Xia et al., 2023).

The perceived impacts of AVs on urban mobility systems have been tested using various methods, including modelling, surveys and critical analyses. AVs have the potential to significantly improve road safety, reduce emissions, optimise travel time and lower congestion levels (Severino et al., 2021). However, their successful implementation requires more attention. Kalatian and Farooq (2021) use immersive virtual reality to analyse factors which affect pedestrian behaviour in the presence of AVs. Guerreiro Augusto et al. (2024) show how automated mobility becomes intertwined with distributed AI and the platform economy in developing urban automated transport systems. Their 'architectural blueprint' provides an initial entry point into "building effective and efficient MaaS solutions for citizens" (Guerreiro Augusto et al., 2024, p.9). Gouni, Kehagia and Nalmpantis (2022) argue that carsharing services must be a central component of any proposed automated urban mobility system to achieve the desired sustainability results and positively affect demand for public transport. From citizens' perspectives, survey data shows that respondents exhibit an overall positive acceptance of last-mile autonomous shuttle services, but with a limited willingness to pay for them (Camps-Aragó et al., 2022).

Trials on pedestrian detection by AVs revealed significant safety risks for pedestrians and human drivers. The researchers call for a re-evaluation of "performance standards for cars that embed probabilistic reasoning, since it is clear from [their] results that despite manufacturers' promises of improved safety, vehicle pedestrian detection can be highly variable," citing an October 2023 incident in San Francisco in which a driverless vehicle struck a pedestrian (Cummings and Bauchwitz, 2024, p.8). That incident led to robotaxi company Cruise's indefinite suspension in California (Cano, 2024). News reports have further pointed out the disruption AVs have had in city systems, such as interfering with firefighting duties (Angwin, 2023). The lack of national regulatory standards in the US for AV safety testing is just one example of the policy challenge cities face towards reaping the benefits of automated mobility systems. Pande and Taeihagh (2023) present Singapore as a case study into the necessity of government involvement for coordinating robust regulation and addressing complex issues such as ethical dilemmas and social connectedness in governing autonomous systems. There is a diversity of approaches to the negotiation of urban road space between AVs and pedestrians, from those centring analyses of technical developments to those speculating the outcomes of possible policy responses.

3 Nexus B: People, devices and data

Kellerman (2023) refers to the "virtual mobility" of today's technology presenting users with new opportunities for human interaction as well as the extensibility of the self. Mobile users are equipped to exploit real-time information through a combination of devices, services and algorithms while moving through urban areas (Miller et al., 2021). Current initiatives into understanding hybrid-urban space range in focus, methods and intended outcomes. HybGen: Young generations trapped in hybrid lifestyles is a research project based in Oslo and Lisbon focusing on survival strategies employed by young adults in the domains of housing and work amid urban digital transitions (Dinâmia'cet-Iscte, 2024). Another example is the Massachusetts Institute of Technology's Smart Curbs (Senseable City Lab, 2023), which uses sensors attached to public buses to analyse real-time data on how urban sidewalks are being used. Hybrid technologies are actively reshaping public spaces, as seen with Pastguide, a collaboration with the Historical Museum of Krakow and Rarelight Immersive that used mobile devices to extend the cultural institution into public space while collaborating with local vendors (Filipowiak, 2020).

Plenty of research exists on pedestrians' sensory distraction via mobile use in public spaces. Methods include observational studies, surveys, agent modelling and experimental procedures involving technologies such as eye-tracking systems. Mobile use was found to be widespread by pedestrians, affecting street crossing behaviour (Frej et al., 2022) and increasing inattentiveness on streets (Gruden et al., 2021). In other high-traffic areas, such as transit stations, mobile use by pedestrians is more likely to disrupt the efficiency of traffic flows (Shen et al., 2022). These types of inquiries tend to focus on the impact of technology use on pedestrians' movement and physical engagement with the environment around them. Other inquiries look at the effect of digital technology use on mental, social, or other forms of engagement with urban areas.

Lu (2023)'s study asked participants to take leisure walks through an urban centre while engaged with their mobile phones, commenting on how the devices "[reconfigure] the space-time relationships between a pedestrian and their surroundings". Pedestrians' interpretations of their surroundings were found to be supplemented by mobile use in a complex interplay between "various sensory inputs, memories/lived experiences, spatial knowledge, urban design, habits, personal interests and preferences" (Lu, 2023, p.90). Kalin and Frith (2016, p.223) argue that smartphones and wearable tech "have become the invisible infrastructure for the production of embodied space" in urban settings. Through devices which navigate, capture and represent space, pedestrians combine both data and rhetorical memory in new forms of urban interaction. By the network logic which enables urban digital infrastructures, hybridity in public spaces enables new forms of interconnection and sociability between users (Xu et al., 2023).

The integration of the internet of things devices (the network of physical devices, vehicles or appliances that share data) into the built environment creates urban data infrastructures which affect physical everyday systems in cities (Barns, 2020, Dodds et al., 2021). Location-based services and technologies integrate data and virtual objects into the embodied cityscape which is otherwise experienced physically through human senses. Widespread use of smartphone applications results in the production of spatial and demographic data, possibly unknown to both data subjects and city authorities (de Souza e Silva, 2017). Pedestrians are subject to invasive sensors by commercial third parties in the "digital public space", the majority of which are unaccounted for and constitute a serious privacy threat (Marsic, 2022). Possible policy solutions to public data exploitation include the city of Amsterdam's approach which requires commercial actors to register any sensors installed in public spaces or the city of Leeds's questionnaire to suppliers of technology. In a report published by the Open Data Institute for Arup, researchers explore options for data-sharing infrastructures, including data-sharing agreements, data pooling, and decentralised open data (Dodds et al., 2021). Data infrastructure, like physical infrastructure, must be assessed on the grounds of resilience, longevity, and access to equip cities with the necessary tools to tackle future hybrid developments.

4 Nexus C: Public space and street design

The future of AVs on roads and the increasing hybridisation of public space has prompted urban planners to think about the necessary design changes that are needed to improve safety, efficiency and citizen engagement. The deployment of AVs in urban areas could lead to more efficient land use, reduced parking needs, reduced emissions and improved air quality (Orieno et al., 2024). Roadway infrastructure is an immediate area for consideration; models of the effects of dedicated AV lanes in diverse roadways estimate that at a higher market penetration rate, dedicated lanes could reduce traffic accidents by 50 per cent (Sha et al., 2024) and substantially increase ridership (Zhang et al., 2023). However, though changes to roadway infrastructure may influence activity surrounding vehicle use, pedestrian behaviour is less affected (Zou et al., 2023). Cummings and Bauchwitz (2024) also show that increased markings on roadways risk lowering the performance of detection systems in AVs. Plihal et al. (2022) propose an automated urban parking system with a communication protocol that connects AVs, parking infrastructure and drivers. The field of urban design, equipped with emerging and refined hybrid technologies faces new issues in the face of ongoing technological developments in public space.

From models to real streets, changes in urban design involve several physical and digital components that must be accounted for. Effective and sustainable adoption of AVs in cities requires both digital infrastructural development and legislation to promote commercial uptake (Jovanović et al., 2023). Rather than simply matching city designs and policies with AVs' technological innovations, Sandhaus, Ju and Yang (2023) propose iterative simultaneous prototyping of AVs, city designs and policies. On pedestrian behaviour, Kalatian and Farooq (2021) suggest educational programmes, enhanced safety measures, active modes of transportation and traffic rule reform as potentially viable and urgent interventions. The interconnections among AV, city and policy design decisions can be mapped to identify the key barriers in combining them. Implications of hybrid technology on urban design extend beyond roadways and crossings and into heavy pedestrian traffic areas such as metro transit stations (Shen et al., 2022) and retail centres. The design processes of these spaces necessitate a systems approach to attend to all involved actors accurately and holistically.

5 Conclusion

Hybrid public space demonstrably involves several co-dependent systems including but not limited to AVs, public digital infrastructure, street design, hybrid pedestrian culture and policy responses. Digital technology, human behaviour and the regulatory approaches of cities are co-evolving continuously. It is necessary to apply a systems perspective to prepare cities for future shocks in this complex ecosystem. The urban hybridity framework presents a modularised and layered approach with accessible entry points to an otherwise overwhelming set of issues.

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[i] See Rode, P. and Bhargava, S. (2024). Hybrid Cities: Conceptual Framework. LSE Cities Working Paper.