CITY CENTRES IN THE ERA OF SELF-DRIVING CARS: POSSIBILITIES FOR THE REDESIGN OF URBAN STREETSCAPES TO CREATE PEDESTRIAN-ORIENTED PUBLIC SPACES

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Abstract. The forthcoming popularization of Self-driving Vehicles (SDVs) suggests a significant challenge in urban planning, as it enables new mobility patterns for urban citizens. While manufacturers have been developing visionary scenarios where cars become rentable mobile activity spaces, the impact of SDVs on the urban context is unclear. Through the analysis of the new social and technological functionalities developed by car manufacturers, and the projection of these functions into spatial scenarios of use within urban case study site, this paper explores the potential for the redesign of urban streetscapes to reclaim open spaces for pedestrian experiences and urban culture.

Keywords. High-density urbanism; Self-driving vehicles; Urban analytics.

1. Introduction

Since the advent of the Modernist doctrine, road infrastructure has dominated urban planning, in many cases segregating community fabric by wide roads (Flint, 2009). Car companies play an influential role in promoting the use of private vehicles, which undermines pedestrian's interests (Schwantes, 2003). As the auto industry plans to launch Self-driving Vehicles (SDVs) for the market by 2030, it is foreseeable that our urban environment will be impacted by another phase in the automotive revolution.

Despite the development of SDVs keeps accelerating in recent years, there is limited research on their impact to the urban environment. The main contributors to speculations about the impact on urban environments by SDVs are governments and car companies. An example is the 'Blueprint for Autonomous Urbanism', an urban design guidebook published by a governmental organisation to suggest pragmatic policies solutions to accommodate the arrival of SDVs (NACTO, 2017). This publication suggests a mild revision of existing street designs, by widening street space for pedestrians and cycling, and reducing space for vehicles. It assumes that large scale public transport, such as buses and trams, will continue to play a significant role in future cities. However, the usage of ride-sharing services with sedan size vehicles may dominate the majority of local transportation (Fehr&Peers, 2018). The Blueprint explores to a small extent the

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potential of designing flexible and dynamic urban spaces, but largely promotes the categorisation of different transport modes into lanes, while SDVs would not need these. On the other hand, publications by car companies explore future usage scenarios surrounding SDVs, visualising innovative uses of vehicles but without exploring the impact on the urban environment. A project from Ford titled 'The City of Tomorrow' with SDVs was subsequently criticised by urban planners as it depicts future cities with Modernist urban planning elements such as elevated walkways and wide road sections, resulting in low walkability (Speck, 2020).

The possibilities of autonomous vehicle systems, as they have been announced by car developers, point to the emergence of new urban mobility systems that extend beyond the scope of the vehicles themselves, as they inform issues such as ownership, management and spatial distribution across urban areas. The technical features of self-driving vehicles, such as sensor-based responses, route coordination in relation to other vehicles and real-time user inputs through mobile applications, allow conceiving traffic management in urban areas as a computationally controlled eco-system which can be adjusted dynamically to satisfy collective interests. Their capacity to improve pedestrian safety, road efficiency and function as an adaptive form of public transport, allows for the radical rethinking of urban streetscapes and of the use of urban open spaces. The possibilities for self-driving vehicles to function as mobile offices, shops, restaurants or hotel rooms open up new scenarios for the distribution and mixing of activity patterns of urban residents across urban centres and throughout the day.

The aim of this study was to explore a possible future scenario for the reshaping of urban open spaces, based on evidence of the new functionalities as they have been presented by self-driving car manufacturers. It adopted a research-by-design approach, using a case-study site in Tuen Mun New Town in Hong Kong to explore processes of urban transformation, public space planning and a data-driven distribution system for SDVs that prioritises human agency and collective social engagement.

2. Self-driving Vehicles' Opportunities Beyond Transportation

SDVs have advantages over conventional modes of transport, as they do not require driver's input and secure safe travelling thanks to controlling systems and the real-time analysis of the route environment. The possibility of conducting activities other than driving during travelling has been addressed by car designers in various speculative visualisations and prototypes. For instance, Toyota is developing its SDV system 'E-palette' with different modules like shops, restaurants, offices and hotel rooms (Toyota Motor Corporation, 2018).

Besides accommodating different interior activities, the overall anatomy of self-driving vehicles is also likely to change. Israeli startup Ree revealed a flat electric vehicle platform in 2019 that can be combined with different modules (REE Automotive, 2019). These SDVs enable efficiency gains, allowing to swap different types of cabins depending on demand, and for the separate charging of platforms and batteries.

These examples indicate that SDVs could enable productivity while transporting passengers, but could also be used as temporary stationary spaces to introduce additional functions into open urban spaces.

3. Possibilities for Changes to Road Infrastructure

There is a range of technical innovations for controlling the movement of SDVs, either individually in response to their environment or as a collective system, by coordinating movements across multiple cars. Car companies have been developing a ‘platoon’ mode of travelling, where SDVs can travel in clusters at high speed to minimize road occupation and also wind resistance. This functionality implies that road capacity and efficiency can be significantly increased, resulting in narrower and fewer lanes for expressways and trunk roads (Zhang, et al., 2020).

SDVs‘ ability to detect obstacles with sensors and manoeuvre safely around them, allows for the adoption of shared road systems. This principle allows for the removing demarcations between vehicles and pedestrians at low-speed sections, which benefits pedestrians’ freedom of walking. Originally introduced by Hans Monderman in The Netherlands, well-known examples of the Shared Space principle are Exhibition Road in London and New Road in Brighton. Research on the traffic movement in both sites indicates that shared road systems create the flexibility to give priority to different users groups in different traffic conditions (Anvari, et al., 2016).

According to researchers, the shift from private ownership to on-demand ride services will reduce the demand for parking facilities between 67% and 90% (Zhang, 2017). Meanwhile, charging facilities can be placed on the outskirts of urban centres to avoid interference with public spaces. Due to their lower cost and flexibility, on-demand ride services could also replace conventional transportation such as minibuses and light rail. Subsequently, related infrastructure including stations and stops can be removed, releasing a significant amount of urban space for pedestrian-oriented planning.

4. Traffic Problems and Opportunities in Existing Urban Centres

To explore the changes to urban environments made possible by SDVs, a central urban site in Tuen Mun New Town in Hong Kong is selected as a case study area. The site represents ‘high-income, dense cities’ in Asia that are predicted to have the highest level of adoption of self-driving vehicles by 2030 (McKinsey&Co, 2016).

As almost 70% of the working population in Tuen Mun commute to work in other districts (Census and Statistics Department, 2016), the quality and experience of daily travel greatly impact people’s quality of life. Wide roads with limited and difficult crossing, high footbridges, congestion and inefficient public transport connections contribute to a negative travel experience. Barriers caused by road infrastructure reduce public space usage by the community as a whole, and people with limited mobility in particular.

While Tuen Mun Highway experiences limited congestion during rush hour periods, minor roads around the town centre are congested for most of the time.

This is caused by a considerable amount of traffic flow to retail destinations, where traffic lights and limited parking and drop-off locations cause delays to an oversupply of private cars. This congestion does not only lengthen travel times but also affects pedestrians through the added noise, pollution and safety risks.

There is a wide range of literature advocating for well-designed streets. Jacobs and Appleyard established the values of public spaces and streets as platforms for ‘good city life’: “Liveability, identity and control, access to opportunity, imagination and joy, authenticity and meaning, community and public life, urban self-reliance, an environment for all” (Jacobs & Appleyard, 1987, p. 115). A recent publication titled ‘Streets for People’ offers that streets should perform well in both as a link and as a place. ‘Link’ refers to the directness of street connection, which is expressed in time, based on an average walking speed. ‘Place’ refers to a street that has activities that allow pedestrians to spend time, such as parks and shops. This parameter is quantified by measuring the number of activities on street sections (South Australian Active Living Coalition, 2012).

To assess the impact of traffic infrastructure on the walking experience in Tuen Mun, several routes from residential districts to popular places in Tuen Mun were assessed according to the ‘Streets for People’ method. Most of the routes are not performing well as both link and place, due to the many crossings or footbridges, and sections that do not have any active street frontage programming. Traffic lights at intersections cause waiting times in unpleasant conditions, and routes forced along seven-meter-high footbridges do not contain any additional functions that would animate the spaces (Figure 1).

The urban planning of Tuen Mun prioritizes vehicles over pedestrians, where wide roads and traffic lights contribute to the unpleasant walking experience. In the subsequent research-by-design section, the potential of SDVs will be explored to maintain traffic volumes yet offer improved urban environments for pedestrians.

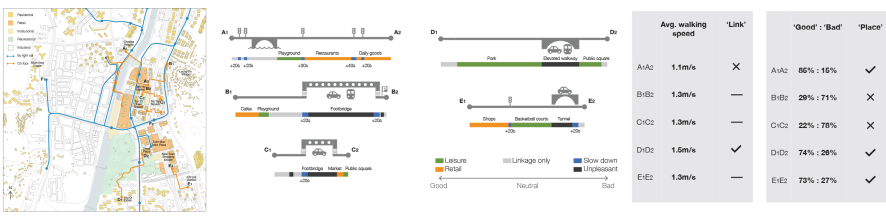

Figure 1. Street Quality Analysis, showing pleasant in orange and green colours and unpleasant sections in blue and grey colours.

5. Tuen Mun Town Centre: An Epitome of Urban Problems

A 1 x 1 km area was chosen for a speculative redesign, which contains the approximate area of Tuen Mun Town Centre. The site contains many of the urban experience issues described above, including wide road sections and poor ground-level walking experience. Walking routes within Tuen Mun Town Centre are obstructed by ground traffic, as the ground level serves as a large transport hub for public transport, including minibuses and a local light rail system (Figure 2). As a result, the majority of the people flow is at the first upper floors, where a public plaza and the main entrances to the town hall and library are accessible via an elevated pedestrian level and several footbridges. This elevated system, however, lacks the clarity of orientation, animation and freedom of route choice, and a majority of it consists of privately owned public spaces controlled by retail mall operators.

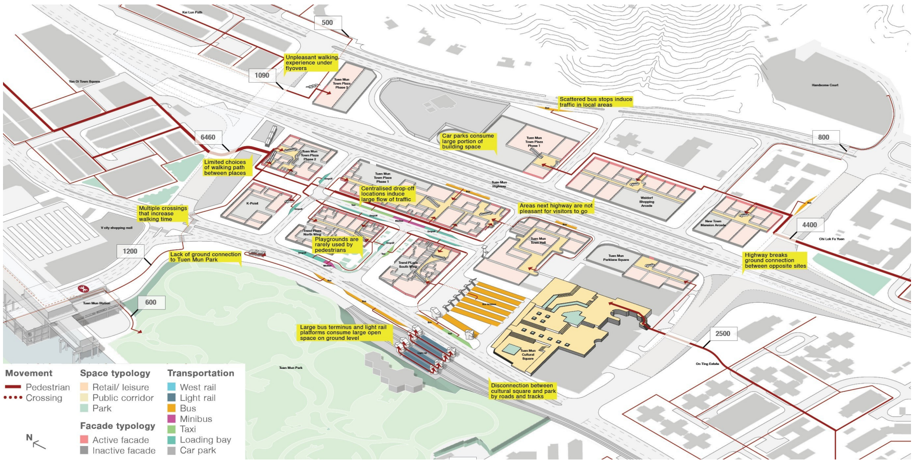

Figure 2. Current pedestrian flow at ground level in Tuen Mun Town Centre.

6. Adaptive Traffic Management Based on Self-driving Vehicles

The large-scale adoption of SDVs offers the opportunity to redesign urban streetscapes based on the cars' integrated technologies for improved safety, control and management. This research-by-design study explores the possibility of removing road infrastructure, pedestrian barriers and parking spaces, to create a shared road space that prioritises pedestrians' freedom to navigate and socialise. Urban trunk roads such as Tuen Mun highway would continue to facilitate high-speed traffic, and therefore should retain barriers for safety reasons. Local distributor roads could be transformed to allow SDVs to plan routes freely at low speed used the 'Shared Space' principle, without fixed lane demarcations of pedestrian intersections.

Within these shared spaces, the movement coordination of all cars in the area would be controlled through a centralised computational system, allowing cars cluster together to free up space and time intervals for pedestrians (Figure 3). During peak hours when there are many vehicles, SDVs can be programmed to travel at moderate speed along planned paths, giving priority to the vehicles and instructing pedestrians to cross paths at specific locations or time intervals. During off-peak hours when demand for using SDVs is less, the cars can be programmed to prioritize pedestrians movements, slowing down or diverting routes to allow pedestrians to walk uninterrupted (Figure 4).

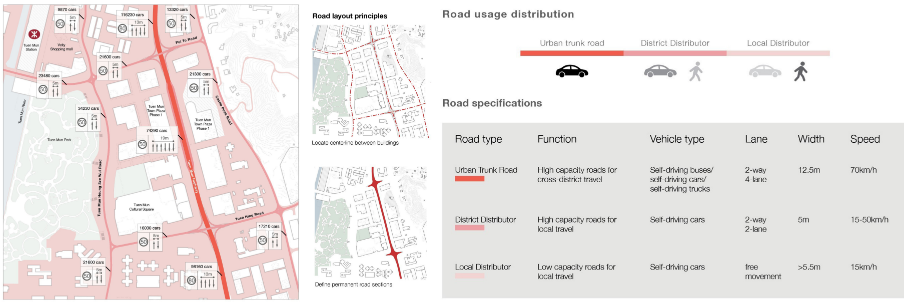

Figure 3. Road system in the future with shared roads (pink) as major public spaces.

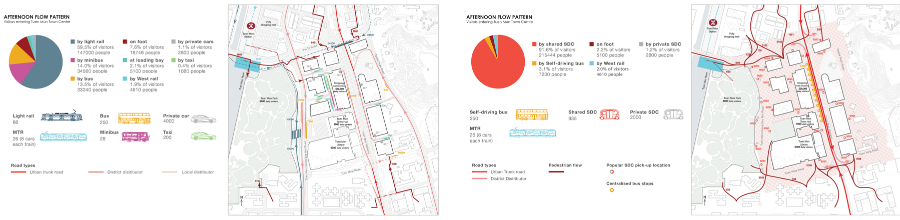

Figure 4. Types and volumes of different transport movements currently (left) and in the predicted future system (right) during off-peak hours.

7. The Introduction of On-demand Mobile Functions in Shared Spaces

On the case study site, the introduction of SDVs and the associated restructuring of transport systems would free up an open ground of approximately 10 hectares for public use. In order to maximize the opportunities for social processes on this common ground, there should be a system utilizing shared data to allocate space, which would encourage spontaneous activities at different periods during the day, and a new walking experience for people passing through the area.

This projection points to an important aspect around the control of these new types of dynamic spaces, that this should be managed as a public open space rather than allowing it to be dominated by commercial interests. 'Public space' refers to the ownership of the spaces, but also to assure that people from all layers of society are welcome to use the space. 'Open space' in this context would refer to the principle that the decisions about the materialisation of urban spaces are open to input from all citizens. Following the principle of 'The Right to the City' (Lefebvre, 1968; Harvey, 2008), the amounts and functions of SDVs in urban centres should be subject to governmental oversight for the purpose of enhancing collective interests and the quality of urban spaces.

A reference to support the idea of 'common ground' proposed in this case study is the open structures explored by Archizoom. In the 1969 project 'No-Stop City', an infinite grid of sheltered space is provided for people to choose freely where and how they would like to inhabit the space. While basic facilities such as bathrooms were provided, actions and activities were all determined by the users (Branzi, 2006). Similarly, the idea of common ground in this project is to aim for minimal intervention on open space usage and let users decide and negotiate.

8. Dynamic Adaptation of Public Space

This research-by-design proposal reveals the opportunities of a large and flexible public open space, keeping the area free of permanent fixtures to maximise the potential of a dynamic configuration of activities enabled by SDVs (Figure 5). Similar to current on-demand services such as Uber, functions can be allocated based on real-time user input, using geolocation data and electronic payment systems. Functions could be physically located near areas where there is a higher number of (anticipated) requests, opening the configuration of the space up to a democratised or market-driven system of dynamic demand and supply.

The project explores the possibility for a control system of SDVs that is not just based on the number of vehicles allowed in a certain area perimeter, but that is spatialised within the open spaces of the city. Using interactive maps accessible to both providers and users of mobile services, a spatial negotiation can take place based on proximity, cost, and attractiveness or quality of the service. To facilitate temporary static functions enabled by SDVs such as food trucks, mobile meeting rooms or grocery shops, public spaces can be subdivided into grid-based plots, where each plot can document real-time and statistical data on current and past uses. This data system, which is similar to current Google Maps functionalities, should be accessible to all stakeholders to facilitate an equitable allocation of space and services.

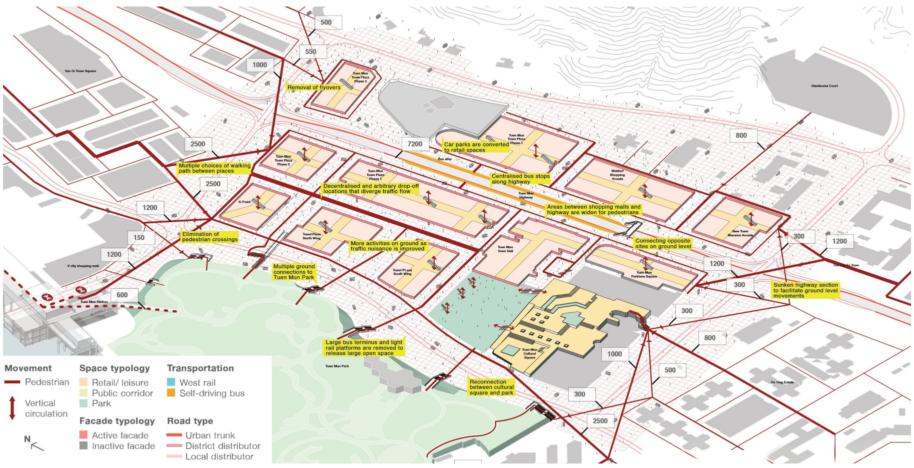

Figure 5. Future scenario of ground level pedestrian flows, following a comprehensive redesign of traffic systems and public open spaces in the area.

9. Case Study Scenario Simulations and Visualisations

To test how the choreographies of SDVs could result in more open space, dynamic configurations of functions and improved social processes, several scenarios of vehicle distributions and flows were modelled using animation software. This exercise allowed to verify the capacity of the road spaces and the urban area as a whole, modelling the same number of trips as in the current situation, based on government data on road traffic volumes and public transport usage. Three periods of a day were chosen to play out different scenarios for SDV movements, including the morning rush hour, mid-afternoon, and evening periods.

For the morning is rush hour period, the large number of commuters travelling between residential locations requires SDVs to be prioritised over pedestrians. The shared road systems are switched to district distributor road protocol, organising vehicles in compact clusters with 200 m distance gaps in between, to enable 20 seconds pedestrian crossing opportunities at one-minute intervals. Dynamic signals assure pedestrian safety while the maximum speed is capped at 50 km/h. It is assumed that a percentage of residents will prefer to use privately owned SDVs, and the majority of commuters will use public transport for cross-district commute, in the form of self-driving buses and the MTR. People living further than 10 minutes walking distance from a regional transport station would use shared self-driving shuttle vehicles, while the improved walking environment invites local people to walk to stations. Along the main walking routes, catering vehicles are stationed to provide breakfasts, informed by real-time data on people concentrations and demand. Local companies can position mobile office vehicles in the most convenient locations to bring collaborators together for meetings or events, while other spaces in the common ground are reserved for social services to serve different groups within the local population. Functions such as health and exercise programmes, education and elderly support are enabled by specialised vehicles distributed near target audiences (Figures 6.1, 6.2, 6.3).

During the afternoon, local pedestrians and street activities are prioritised, and SDV movements in the area are limited in number and to a maximum speed of 15 km/h. This allows vehicles to dynamically avoid pedestrians who can walk freely in the shared road spaces. Existing retail malls can be expanded with retail and social activities at neighbouring public spaces, using stationary shopping vehicles to configure outdoor market areas. As the current retail malls are organised around elevated pedestrian corridors, these markets help activating the neglected ground-level shopping experience. Similar to the morning scenario, part of the public space is reserved for cultural programs and social services (Figures 6.4 & 6.5). At night, the public spaces are used for parked vehicles that function as mobile homes or micro-apartments, to address the shortage and unaffordability of housing in the local area (Figure 6.6).

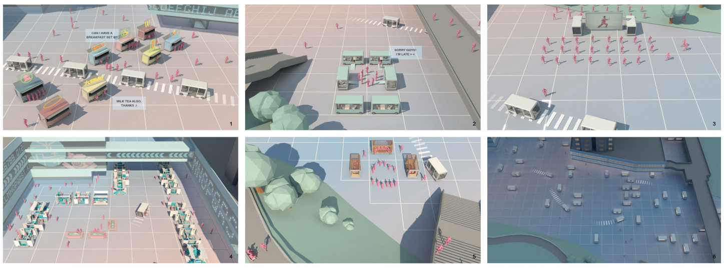

Figure 6. 1)SDVs with food truck modules arranged for commuter pedestrian flows. 2)Mobile workspaces cluster for company employees. 3)Morning exercise area for elderly residents. 4)Temporary market arrangement with additional seating to activate public spaces outside the existing retail mall. 5)Street performance surrounded by seating provided in parked vehicles. 6)SDVs stationed as additional micro-apartments to alleviate the housing shortage in the area.

10. Conclusions

The introduction of SDVs at large scale into urban centres offers several opportunities as well as potential challenges. This paper argues that in order to avoid the over-congestion of urban streetscapes by wide range of commercially operating vehicles, the amount and spatial distribution of SDVs should be controlled according to criteria that ensure public spaces that are pedestrian oriented and inclusive. The technologies that ensure coordinated, safe and responsive vehicle movements allow for the removal of traditional safety measures that limit walkability such as pedestrian crossings, barriers or footbridges. The increase in road use efficiency and the reduced need for parking allows for a reduction in road space, freeing up vital space for better quality pedestrian spaces. Shared space principles in low-speed traffic areas can be managed to prioritise pedestrians during most periods of the day, while platooning protocols during rush hour periods can still allow for opportunities for same-level crossing, which increases the walkability of urban centres.

The additional functions of SDVs allow for the merging of travel and productivity time for commuters, and also for choreography of temporary spaces stationed around urban space to serve pedestrians. This ability suggests new urban space experience and management, where the real-time negotiation between supply and demand produces dynamic fluctuations of vehicle and people flows.

The case study design and simulation exercise in Tuen Mun Town Centre has produced a vision on how future cities could operate, bringing changes to the physical urban landscape as well as to the social and cultural facilities of the area. Commercial operators are welcomed to bring additional vibrancy and customised services to local residents, but it will be necessary to assure that a proportion of the space and services is reserved for vulnerable groups.

While this study has aimed to speculate on the general organisational, spatial and social consequences of introducing SDVs into urban centres, several different types of studies could be undertaken to further develop the traffic and urban planning concepts explored here. While many of the technical possibilities will likely be developed by the industry, we argue that urban designers and city authorities have the urgent task to envision policies for the management of SDVs, to maximise on the positive benefits that these can bring and to support the expansion of vibrant, supportive and inclusive urban spaces.

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