WHO'S DRIVING?

A Manifesto for City Centres in the Age of the Driverless Car

steer davies gleave

This work is a collective effort of an interdisciplinary team of professionals at Steer Davies Gleave. It has involved experts in urban design, architecture, intelligent mobility, transport planning, landscape architecture, and highway engineering. The project was completed in March 2018 and coordinated by senior staff of our Urban Design team.

This work was generously funded by the Steer Davies Gleave's Research & Innovation programme.

This work addresses plausible future scenarios, rather than forecasts, and represents the views of the Design for Movement and Intelligent mobility teams. However it is not company policy or intended as a work of advocacy.

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INTRODUCTION

1. INTRODUCTION

According to the latest industry predictions, Connected Autonomous Vehicles (CAVs) will become a reality in the wealthiest urban environments within the next 10 years. How will this shift change the faces of our cities? And how will this evolution unfold?[1]

This report speculates about the ways in which this imminent change in urban mobility and technology may affect the urban form and public realm in cities within the next 20 years. Within this timeframe, the evolution should be easier to predict and plan for, given that the current mobility system will initially coexist with the new one. This scenario increases in complexity as it requires space for both old and new technologies. At the same time, there exists the critical challenge of ensuring a smooth transition to the new technology and without compromising the many potential benefits of CAVs through the ever-pressing necessities of the current car-centric system. It deliberately avoids developing forecasts and rather focuses one of the possible scenarios.

To focus our efforts, we have studied two areas in the central urban cores of Los Angeles and London and have drawn parallels between the two. These cities are emblematic within western societies and display a rich array of the issues faced by cities worldwide. The car paradigm was applied to both, but while young Los Angeles was free to adapt to the needs of the car, old London's constraints led to a different incarnation of the paradigm. In both cases, the effect on the urban form was radical. Once again, urban environments in Los Angeles and London are at the forefront of a mobility revolution that will eventually unfold globally.

As urbanists, we appreciate the benefits that this technological revolution may bring in terms of sustainability, livability, and accessibility, and welcome this leap forward. However, we also value the lessons learned from the mistakes of the last century and recognise that technology is a tool, not a means, and that we cannot afford to shape our city around a new technology and create new infrastructural rigidities.

[1] For current market prediction see the USA National Highway Traffic Safety Administration (NHTSA): https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

As designers, we want to contribute to the debate and help urban dwellers to envision and capitalise on the transformations that this revolution will bring. Urban populations will continue to increase exponentially in the coming years, and the CAV technology will disrupt the business-as-usual model. Mobility, congestion, pollution and sprawl will be among the major challenges facing cities. Tackling these issues will be (and already is) a priority for regional and local policy makers.

On this basis, we have identified a series of design ideas and recommendations for stakeholders involved in city-making – how to best address, prepare for, and exploit these imminent changes, acknowledging that human scale and well-being will remain the fundamental driving principles of urban design.

Who's driving? A Manifesto for City Centres in the Age of the Driverless Cars is Steer Davies Gleave's provocative Manifesto on CAVs and urban design. The Manifesto speculates about how imminent changes in urban mobility and technology could affect the urban form and public realm in the next 20 years. It also proposes ways in which cities could prepare for them. The work focuses on the urban design opportunities that could be created by CAVs in urban cores, in terms of street layout and redistribution of space, on the interface between buildings and streets, on possible ways to re-organise the movement network, on environmental sustainability measures, and on new building typologies.

The Manifesto wants to contribute to the discussion on the possible spatial reconfigurations of our cities as a result of these changes. So far, the topic has seen little attention from architects and urban designers and has mainly focused on the end state, when CAVs will be the only technology.

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SETTING THE SCENE

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2. SETTING THE SCENE

What is changing

Driverless cars are an old fantasy, as old as the car itself, however the technologies required to realise the vision converged and came to fruition only very recently. The rise of CAVs is not due to their potential benefits to the environment and humans (such as improved safety and increased accessibility), although these factors could accelerate adoption by overcoming some cultural obstacles. Instead, the powerful driver to this change is the enormous amount of money at stake resulting from the impending disruption of the current model of the automobile industry. This is why we are witnessing a gold rush involving start-ups, IT powerhouses, and other non-traditional players as well as the traditional car manufacturers. The amount of investment is accelerating the arrival of the next transportation revolution. The latest forecast suggests automation level 4[1] vehicles will be available for purchase within three years in the wealthiest markets.[2]

This level of automation allows CAVs 'to perform all safety-critical driving functions and monitor roadway conditions for an entire trip', but it does not cover every driving scenario. In other words, CAVs will be able to safely pull over and stop the journey if the driver does not intervene in a situation that the CAV's operating system cannot handle. In such a vehicle, the driver could devote part of the time to sleeping, eating, or working on a laptop instead of driving. Level 4 vehicles, are expected to reach the market around 2022 and Level 5 (full automation in all conditions), in 2030.[3]

This timeline is, however, not only reliant on the necessary technology. CAVs will also need to address critical challenges in terms of the regulatory framework, including insurance, as

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[1] Level 4 relates to full automation in controlled areas. Simplifying, there will be no need for a driver, vehicle will be able to handle emergencies and in case of problems safely pull out and stop.

[2] A useful summary of the automakers plans as of 2017 is available at: https://www.techemergence.com/self-driving-car-timeline-themselves-top-11-automakers/

[3] "The IHS predicts 21 million fully or semi-autonomous sold globally in 2035 and a total of 76 million sold between now and then." http://news.ihsmarkit.com/press-release/automotive/autonomous-vehicle-sales-set-reach-21-million-globally-2035-ihs-says

well as public perception. The challenges are significant, but not insurmountable. They can however significantly slow the adoption process.

The current process of urbanisation continues to rely heavily on the automobile to move. In 2008 50% of the global population passed from living in a rural environment to living in an urban or semi-urban one, this passage is unprecedented. During the coming twenty years, Chinese cities will absorb a new population of some 350 million people. The United States will witness a population increase of over 100 million people in the next fifty years. In the UK the population will reach 73 million by the beginning of the 2040s.[4]

This transportation revolution could turn into a nightmare if it is not managed and if we do not prepare for it adequately. Sprawling development, congestion, inequality, privacy issues, and job losses are some of the most pressing challenges that cities will have to face through this transition. Preparing for CAVs is about securing the benefits they offer and mitigating if not eliminating their risks, including that of designing cities around the new technology rather than around people.

[4] Source: https://esa.un.org

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OUR WORK AND OUR ASSUMPTIONS

3.
A POSSIBLE SCENARIO

Many experts believe that one of the much-presaged benefits of the CAVs revolution, apart from safety,[1] will be more efficient traffic operations leading to increased carrying-capacity of existing road infrastructure and less parking requirements, with the potential to reallocate road and parking space away from vehicles to other uses. With the ever-increasing levels of traffic congestion that urban environments will keep experiencing in the coming years, there will be a temptation to simply use the space 'gained' for more vehicles. This strategy could be short-lived. We have seen many times in the past how more and larger roads simply lead, rather quickly, to an increased volume of vehicles on the roads.

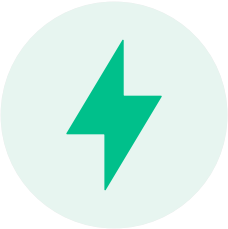
Different scenarios are certainly possible, only time will tell. In the meantime, we take forward one of these and explore the potential for a fundamental rethink of our streets. For instance cities' staff and policy makers could take this opportunity to instigate a paradigm shift and break the cycle of motor vehicle dominance on the streets. They could champion the reallocation of space away from automobiles, to more productive and resilient uses, people and human-scale activities, and finally break the perpetual cycle of traffic-induced demand. With the advent of CAVs, local authorities and policy makers will have a once-in-a-lifetime chance to re-consider how their cities' streets function as part of a movement network, offering a unique opportunity to use the 'extra space' to retrofit their cities in a more context-conscious and sustainable way.

For this work, we have decided to focus predominantly on the next 20 years and tackle the very practical challenges of a transition between current technologies and full automation. The way in which CAVs are implemented at their introduction will inevitably influence their subsequent trajectory, potentially creating infrastructural or cultural rigidities that could affect our cities for much longer than the years of the adoption phase. This could be in terms of separation, attitudes towards

[1] According to NHTSA the safety benefits of automated vehicles will be paramount. Automated vehicles will have the potential to remove human error from the crash equation, which will help protect drivers and passengers, as well as bicyclists and pedestrians. Per NHTSA, as a reference, more than 35,092 people died in motor vehicle-related crashes in US in 2015.

first-last mile, or in other ways that we cannot yet predict. Given the powerful set of variables at play when determining the characteristics of CAVs; how they will be used, the speed of their adoption, and ultimately their effect on the built environment, it is difficult to define a credible scenario that could work as a brief for designers. The further we look into the future the less reliable such a brief would be. To define our setup, we have formulated a series of assumptions. These have been developed by combining our current understanding of the latest market predictions, alongside the input from Steer Davies Gleave's network of Intelligent Mobility experts and transportation planners. We present them in the following pages.

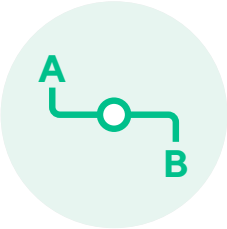
CAVs could be a sustainable answer to urban transportation, open up a post car world paradigm, and create opportunities for resilience and climate adaption thanks to the changes that they could bring to the cities' physical fabrics. In order to do so, we believe that CAVs in urban cores could be:



Electric engine vehicles will almost eliminate the issue of pollutant emissions. Significantly improving cities' air quality and possibly helping kerb down CO2 emissions.

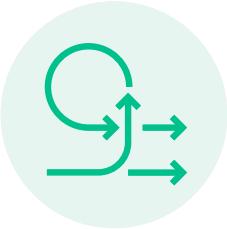
Connected vehicles equipped with technology enabling them to connect to devices, as well as external networks such as the internet and vehicle-to-vehicle (V2V). This will facilitate the efficient use of vehicle fleets and the existing road network. Thereby freeing up space for other and better uses.*

* It is worth notice that cars today are on average parked 95% of the time: http://www.reinventingparking.org/2013/02/cars-are-parked-95-of-time-lets-check.html



A service we imagine the future of mobility to be, is one driven by a mobility provider (public or private). The passenger, over the cloud will give their transportation requirements. The mobility provider will then arrange and send the CAV to the passenger for transport. This service will be part of an integrated range of mobility options for the user, to take him from origin to destination of his trip.

Shared CAVs services should be able to make multiple stops and pick up different passengers going in the same direction. This will expand the number of passengers per vehicle and the pool of users to elderly, teenagers, and disabled. All the while contributing to free more space for other uses.* At the same time privately own single occupancy vehicles could be progressively banned from city cores.



Flexible through public and private partnerships CAVs services could help make fixed mass transport service more functional, efficient and accessible, particularly by filling first – last mile trip gaps.

* The vast majority of US commuters continue to drive to work alone in their cars. Over ¾ (76.3%) choose to commute this way. Regarding latest commuting trend see: https://www.usnews.com/opinion/economic-intelligence/articles/2017-09-18/what-new-census-data-reveal-about-american-commuting-patterns

In 20 years, according to our predictions, our wealthiest urban environments could present a series of defining characteristics:

Vehicles

- Every vehicle will be partially automated and at least a quarter of the overall fleet will be fully automated (every vehicle will have an automation level between 2 and 5).[2]
- Every vehicle will be connected and will exchange information with other vehicles.
- CAVs will permit platooning; space between CAVs while moving could be minimal.
- The large majority of vehicles will be electric and will require dedicated charging infrastructure. As a result, there will be little to no pollution emitted by vehicles.
- Most CAVs used in urban environments will be less than 2 meters wide.[3]
- For emergency services, current standards for space and dimensions will still apply.

Streets

- Vehicular congestion will still be an issue, potentially also in CAVs-only areas.
- CAVs will require frequent pick-up/drop-off designated areas, therefore demand for pick-up/drop-off areas will increase substantially.
- Traffic lights and signage will remain even in CAVs-only areas, but will perform differently. The focus will shift to pedestrians and bicyclists and they will be more interactive. New ways to regulate possible conflicts among modes of transportation will emerge.

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[2] The current average age of cars in the EU is 10.7 years (source European Automobile Manufacturers Association, 2017), 11.6 years in the US (source IHS Market, 2016).

[3] This assumption implies the end of a trend inaugurated 40 years ago when the average width increased by 16%. See http://www.dailymail.co.uk/news/article-2103592/How-Britains-favourite-cars-outgrown-parking-bays-average-vehicle-2in-wider-space.html . Change will likely have to be promoted or imposed by regulations and have to satisfy safety requirements.

- New dedicated charging infrastructure will be required. Only part of these will be on-street, the rest will be in dedicated areas and stations. Limited induction charging facilities will be introduced for taxis and buses.
- Reductions in roadway sections will be possible thanks to CAVs' improved traffic flow, with reduction of lanes and overall roadway widths.
- Local CAVs-only streets will be quieter than streets today, with a reduction in traffic noise due to electric engines.
- Street lighting will be experiential and smart.

Parking

- Kerbside long stay on-street parking will eventually disappear, especially in city centres.
- Around 30% of the existing parking supply in urban areas may be redundant – parking in urban cores will still exist near destinations but will be less and will be supplemented by remote CAVs parking locations.[4]
- Car parking space dimensions will be smaller than today as CAVs will require less space to manoeuvre.

Multimodality

- Users' mobility needs will be provided through subscription models (similar to "Netflix"), mostly regulated by the public and run by private operators.
- Increasingly, microtransit CAVs service systems could cover first-last mile trips, connecting to mass transport corridors. These could also be partially if not completely automated, with a hub&spoke model.
- Traditional human driven taxis will be replaced by mobility as a service models and driverless services.
- CAVs and bicycles will compete in urban cores for first-last mile trips.

[4] For more details about our forecast on 'Parking demand in the autonomous vehicle era', see our work in collaboration with KPMG at: https://home.kpmg.com/xx/en/home/insights/2017/07/parking-demand-in-the-autonomous-vehicle-era.html

- Drones for emergency services and, in the long run, personal mobility and delivery will be introduced. These will be increasingly appealing for core to core and hub to hub trips in urban areas with heavy congestion.

Many of these assumptions may not come to fruition. However, we believe that collectively they provide an overall plausible short-term scenario to work with in order to test design ideas as presented in the next chapters.

The values underpinning our proposals

In developing our urban design principles and ideas for city centres in the age of the driverless car, we have been guided by a series of underlying values that we, as urban designers, believe to be at the core of our professional obligations and civic mission. They include fostering human scale design, well-being, and sustainability while adopting these new technologies.

Regardless of the technology, we believe that urban design should always promote, in no particular order:

- **Human scale** and human well-being.
- **Accessibility** as a fundamental right and an issue of justice and democracy.
- **Walkability** and **bicycling** as core strategies to sustainability.
- Strengthening the **social** infrastructure and the sociability of places.
- Maximising opportunities to improve/preserve biodiversity and **resilience** in cities.
- **Densification** as a primary response to accommodate urban growth and to combat sprawl.
- Reintroducing places for **production** in the city, versus a city as a place of only consumption.
- Using data to improve city living and sustainability performances, a **Smart City**.
- Celebrating local **identity**.

4

DISTILLING THE PRINCIPLES

4.
DISTILLING THE PRINCIPLES

In this section, we present Steer Davies Gleave's urban design principles for city centres in the age of the driverless car. We have formulated seven initial principles to help guide interested stakeholders in shaping the future of city centres in the CAVs era, but also, to prompt a much-needed debate on the subject.

The seven principles are:

1

Design streets not roads.

2

Keep it legible.

3

Share CAVs, share streets.

4

Reallocate space.

5

Phase out cars.

6

Enable new architecture.

7

Make it resilient.

These are discussed in further detail →

1

Design streets not roads.

Over the last 20 to 30 years many cities have made huge progress in addressing the modernist mistakes of car-led city planning, dismantling the barriers that were created when traffic efficiency was the driving force. These barriers destroyed many streets, separating pedestrians and cars, as well as bicyclists (or ignored them completely). We should not forget the mistakes of the past in the rush to embrace the future. Cities are for people and we should design streets, not roads. We need to use this new technology in a people-centric manner and continue to pursue the aim of improving our cities for everyone, not prioritising the efficiency of CAVs over other modes and users.

2

Keep it legible

The street has evolved over centuries and it is the lens through which all city dwellers experience and interact with the world, ranging from the everyday experience of one's residential street, to the heightened enjoyment of a bustling boulevard. We should be careful not to lose this understanding and experience of streets in the rush to embrace the new technology. Street design is nuanced according to local situations and preferences, however the overarching language is the same the world over. We should take this into account and help ensure that people will continue to be able to read and understand the street environment, regardless of the technology within it. There could also be an opportunity to enhance aspects of street design, develop design approaches that better respond to pedestrian and bicyclist needs and find ways to make CAV behaviours understood by people.

3

Share CAVs, share streets.

The use of CAVs on city streets should be underpinned by the principle of sharing the street environment and infrastructure with other road users. The ethos of sharing should also be promoted in terms of CAV ownership and usage. In this way, space can be maximised for people, enhancing liveability and activity on our streets.

4

Reallocate space.

With the arrival of CAVs, we will have the opportunity to re-consider how our street hierarchies function as part of movement networks. To maintain a pedestrian-first approach to street design we should not simply allow all city streets to be dominated by CAVs. Conversely in order to ensure that CAVs will operate as efficiently as possible, we may not wish to allow CAVs and manual vehicles to mix on all streets. Space allocation should be considered at a macro level taking a layered network approach in order to allow all different modes to operate.

5

Phase out cars.

For CAVs to create the paradigm shift that we desire in our cities with its consequent benefits, we will have to take steps to phase out manually driven 'old' cars, through regulation and through design. However, there will necessarily be a long transition period where both vehicle types will be on the road. During this period measures should be taken to prioritise CAVs.

6

Enable new architecture.

With the progressive introduction of CAVs for urban mobility, there will be a need for new kinds of building types, to respond to an emerging new lifestyle and to the shifting paradigm between movement and place in cities.

7

Make it resilient.

The CAVs revolution could also provide a unique opportunity to retrofit cities to be more environmentally sustainable and resilient. As evidenced by daily news, this issue is becoming increasingly urgent: climate change and urbanisation are exacerbating existing infrastructural systems, proving them to be too rigid and inadequate for the challenges ahead, and as a consequence ecosystems are suffering. The space gains hypothesised by switching to a CAV only fleet could be significant. There is a risk however that without taking firm action through design, the space gains could be lost to an increased volume of vehicles. If we make our city cores CAVs only though, we could be more radical in the allocation of space, with major gains for pedestrians and public life through the building of denser, greener, and ultimately more sustainable cities.

OUR STUDY AREAS

5

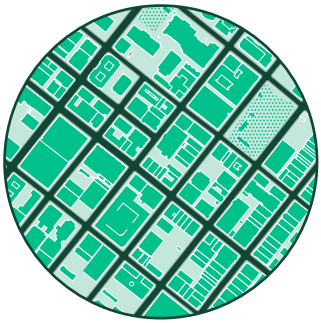
5.
OUR STUDY AREAS

To showcase our principles and urban design ideas we have tested them on two areas in the central urban cores of London and Los Angeles, drawing parallels between the two. These two global cities are emblematic within the paradigm of western societies. The car-based pattern of development took place in both, but while Los Angeles, a relatively new American city, was free to adapt to the needs of the car, London's historic constraints led to a different incarnation of the model. In both cases, the effect was radical.

Once again, urban environments in Los Angeles and London are at the forefront of a revolution that will unfold globally. But while metropolitan London today presents a multimodal approach to its mobility needs,[1] metropolitan Los Angeles relies on the automobile for about 90% of commuter trips[2] and car culture is part of its DNA.

This study suggests how the CAV revolution could prompt the rethinking of these two cores located in very different urban environments, as prototypes of what could be done in American and European cities, and also identify elements that could be transferred to other places.

Shoreditch, London



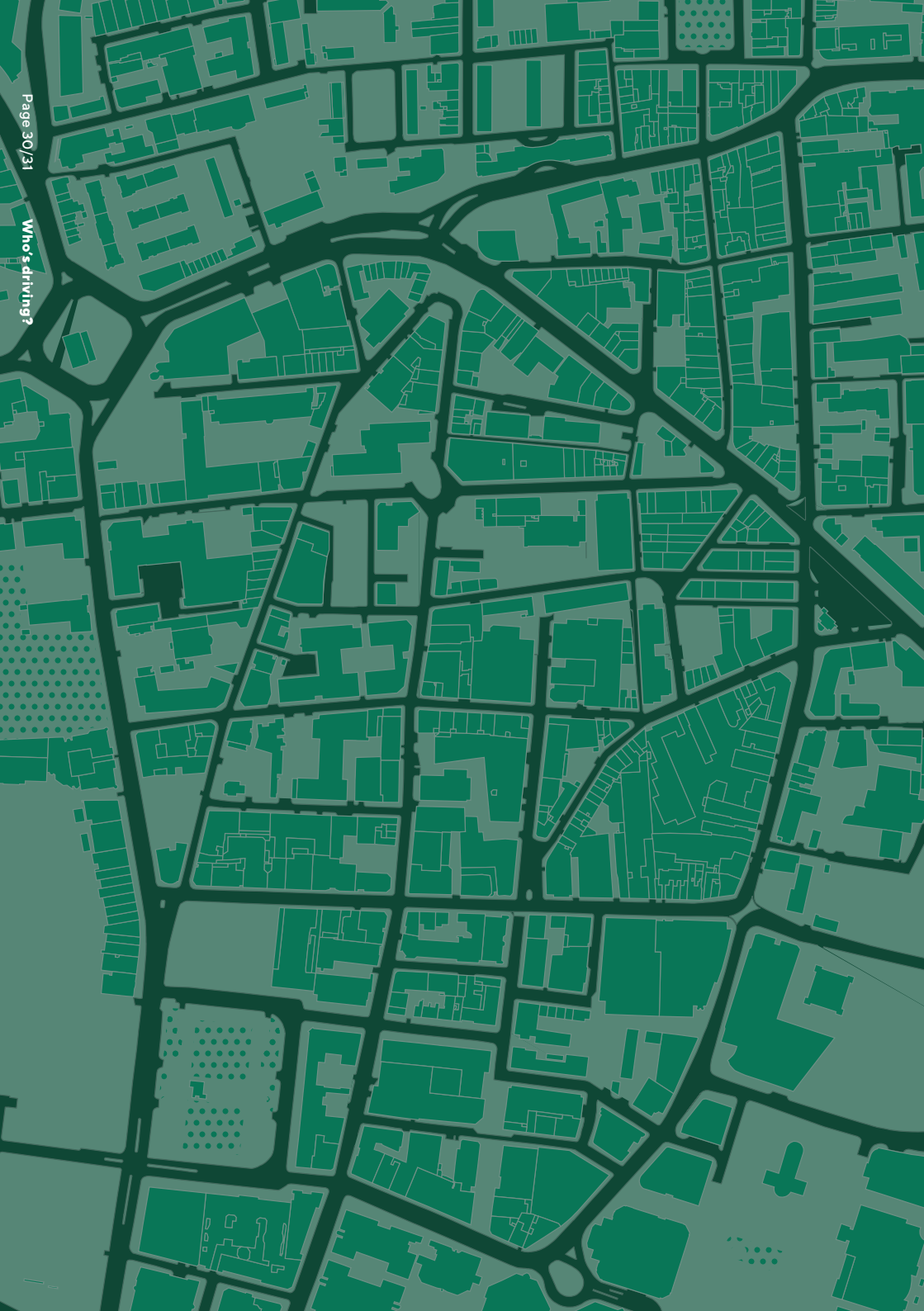
Downtown Los Angeles

Note: maps are drawn at equal scale

[1] See London data on mobility at: https://data.london.gov.uk/dataset/licensed-vehicles-type-0

[2] See Southern California data on mobility at: http://scagrtpscs.net/SiteAssets/ExecutiveSummary/index.html

We started by looking at these two areas for two main reasons: firstly, we believe that urban cores today represent the places where a first deployment of CAVs will occur and where the majority of urban design gains could be achieved if the transition is managed well. Secondly, these two core areas present most of the prototypical characteristics that can be found in similar urban developments in Europe and America, thus providing a test ground for ideas that could be transferable to other cities and contexts.



LONDON

"A man who, beyond the age of 26, finds himself on a bus can count himself as a failure."

- Attributed to M. Thatcher (probably apocryphal)

"I think the key image of the 20th century is the man in the motor car. It sums up everything: the elements of speed, drama, aggression, the junction of advertising and consumer goods with the technological landscape."

- J. G. Ballard

Context

As London approaches the end of the decade, its population is at an all-time high and is expected to reach the 10 million mark before 2030.[1] This has fostered a slow but steady densification process, especially in Inner London which started in the 1990s,[2] and has placed increased pressure on its infrastructure. The Mayor is responding to the challenge with a spatial strategy that prioritises growth around public transport hubs.

Currently a number of high-profile infrastructure projects are being delivered, however the majority relate to rail infrastructure upgrades, extensions or new lines.[3] This approach perpetuates London's renowned tradition of public transport excellence and takes advantage of Londoners' acceptance of multimodal trips.

In terms of road infrastructure, the picture is rather different with the priority focused on making the most from the existing network, which is not expected to improve, either in terms of capacity or environmental conditions.[4]

This is a daunting challenge considering the worsening traffic on London's streets[5] despite a clear bicycling renaissance,[6] the decline of driver's licenses among millennials[7] and the

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1 Source: Greater London Authority and Office for National Statistics.

2 Especially in East and South London. See for instance https://citygeographics.org/2013/09/09/an-urban-renaissance-achieved-mapping-a-decade-of-densification-in-uk-cities/ and London First & Savills, 2015, "Redefining Density. Making the best use of London's land to build more and better homes". The discussion on the construction rate and the prolonged housing crisis is way beyond the scope of this work, however they are crucial topics that also determine the form and type of the densification process as well as its long-term implications.

3 Arup, 2017, "London's strategic infrastructure requirements – an evidence base for the London Plan", GLA

4 The introduction of the Ultra Low Emission Zone in April 2019 is expected to contribute to an improvement of current conditions.

5 According to INRIX's annual report on London's traffic (http://inrix.com/press-releases/london-traffic/) journey times in Central London are increasing by 12% annually. Interestingly the report also highlights the main drivers of this deterioration: planned roadworks, unplanned incidents but also the booming ecommerce market affecting the amount of delivery vans on the street. The report also points out that private hire vehicles (including taxis and uber) are not key contributors to traffic congestion.

6 Daily trips in London have increased 130% per cent since year 2000 (TfL, 2017, "Strategic Cycling Analysis. Identifying future cycling demand in London", June 2017)

7 A 20% drop in under-25s learning to drive has been recorded in the UK.: http://www.telegraph.co.uk/news/2017/07/10/record-decline-teenagers-learning-drive-figures-show/

established decrease of car ownership.[8] Ultimately a large component of this struggle relates to the rigidities of the road networks created by London's urban structure, which, over centuries, has resisted 'modernisation' attempts by eminent personalities including Wren, Nash and Abercrombie. In central London, the combination of the nature of urban fabric and the concentration of jobs creates a fierce competition for space on the street network. The constraints of the network are exemplified by the inner ring road, which includes the busiest roadways, yet is made up of streets with long stretches of narrow sections: Pentonville Road, for example, is 20 meters wide, Commercial Street is less than 18 meters at certain points, Tower Bridge Road is 18 meters wide, and so on.

If we add to this spatial limitation the radial structure of the network and the inadequate offer of orbital routes bypassing the centre of the city, the challenge of increasing capacity while improving environmental air quality and expanding the provision of amenity space appears to be insurmountable.

In this context, the opportunities created by shared CAVs should be looked at very closely, as they could be a strategic tool to solving many of the current issues of London's streets. Provided that the deployment of CAVs can deliver the expected benefits, they will be able to make a difference to London only if rolled out on a large scale. In this sense accelerating adoption is vital. However, this also presents many risks as a hurried implementation could erode, at least in the short term, the quality of London's built environment, not dissimilarly from what happened in the 1960s. London is still decluttering its streets from redundant or over- engineered car paraphernalia, enthusiastically deployed to facilitate the presence of the car in the city while 'protecting' the other street users. But the last thing city dwellers need now is to witness yet another wave of road segregation, especially barriers between pedestrians, bicyclists, traditional cars and CAVs, all to enable the latter to use the streets more effectively.

[8] In 2016, 43% of households do not have a car. However in Inner London the figure is substantially lower. Source: TfL, 2016, "Travel in London. Report 9".

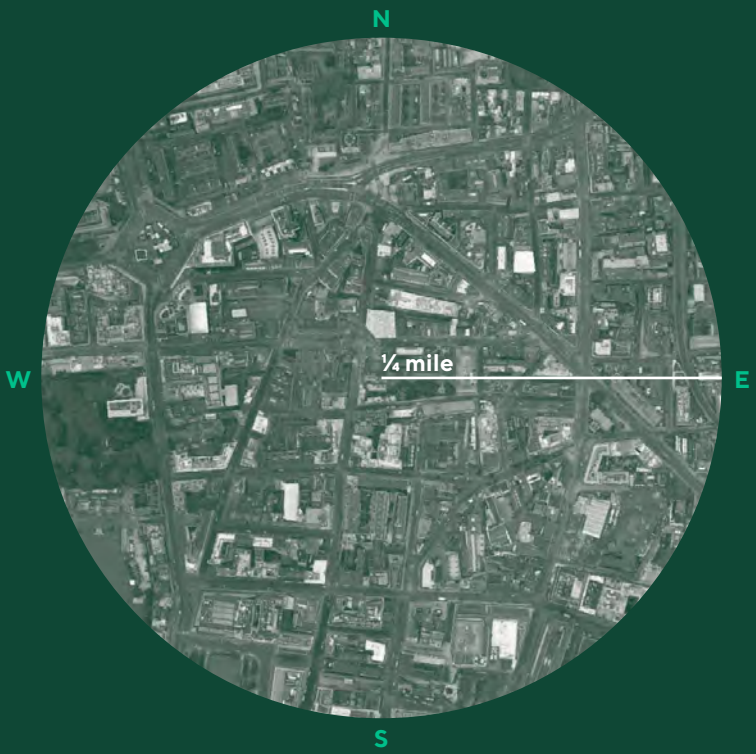
The next moves

If the advantage of using CAVs depends on the scale and speed of adoption, then highway and local authorities in London will be required to take drastic decisions and redistribute space between different users by:

- Allocating dedicated areas to CAVs where traditional cars are completely banned to ensure there is little mixing of the two types of vehicles. If the traffic remains mixed, then CAVs would be little more than an updated version of an electric car e-hailing service and this would dismiss nearly every advantage they offer.
- Upgrading bicycle infrastructure to be much better and faster than what is currently being done. In the short term, bicyclists could be the most disrupting element for CAVs, therefore a world-class bicycle infrastructure separating bicyclists and CAVs on busy corridors will limit conflict with CAVs and respond to the rising demand.

CAV corridors (C-Corridors) could complement the traditional road hierarchy but would not overlap with it. In the beginning, they could be a separate layer that would meet the strategic road network used by traditional cars and public transport only at key points. These connections would consist of a new generation of mobility hubs created to facilitate the switch to/from CAVs and long distance public transit. These are also the places where CAVs would be stored and serviced and would be located along the edges of central London, in dedicated new structures or retrofitted parking garages.

Given the reduced amount of space available and the risk of bringing traffic to a halt with the introduction of CAVs, we believe that initially there could only be a slim network of C-corridors enabling fast, convenient movement from central London to the edges of the inner city, and orbital routes allowing east-west and north- south movement. Progressively, the streets between these corridors could be closed off to general traffic and only driverless cars be allowed. Starting from the centre of the capital, this network would grow to cover the whole city progressively and quickly, as public acceptance becomes the norm and Londoners start enjoying the benefits more and more over the next two decades.



Location of study area in Shoreditch

The Shoreditch paradigm

To elucidate our approach to CAVs in London we have selected Shoreditch as an example, to test our emerging ideas and their actual implications.

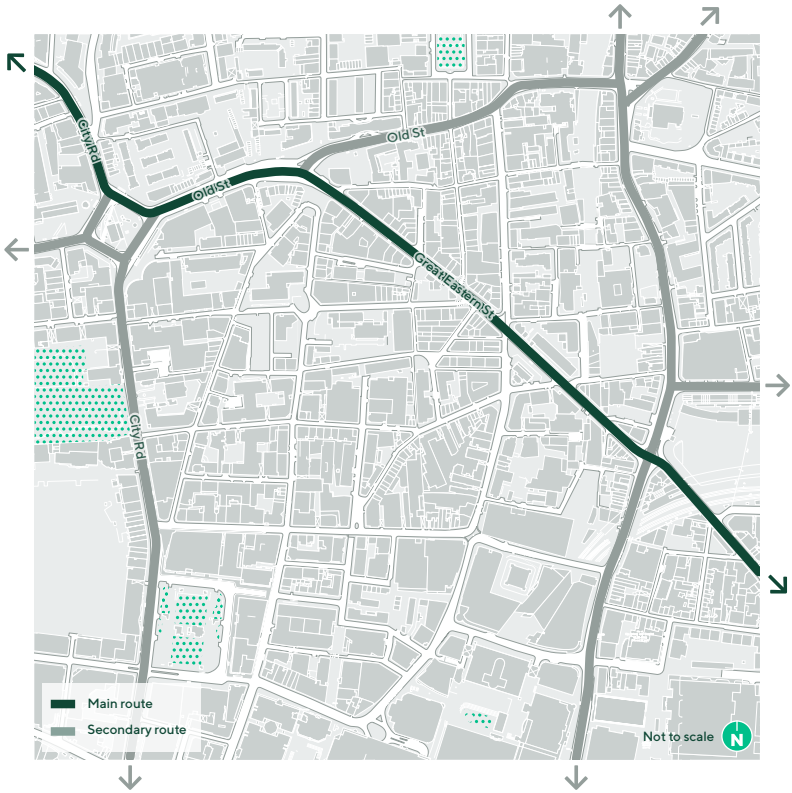
We have chosen Shoreditch because is symbolic of London's complexity in many ways. It features a distinctive range of uses from employment to residential, leisure to culture. Its urban fabric features an eclectic mix of building types from different eras. The area is subject to an intense process of densification typical of many other inner cities across the globe, with many developments completed in recent years and many still in the pipeline. As parks and squares are scarce, its public space provision heavily relies on the street network which is under pressure to respond to amenity, environmental and business demands, in addition to performing its movement functions.

The eclectic nature of Shoreditch is manifest in every aspect of its character, including its irregular layout reflecting historic development. The area emerged organically as a ribbon development along the old Roman Road (now the A10) connecting the City (London's central square mile) to Cambridgeshire and Norfolk. Shoreditch hosts a mix of residential uses as well as leisure and manufacturing activities now deemed inappropriate for the City. The street grid remained irregular until the Victorian age, when incremental improvements (first on Commercial Street, then on Great Eastern Street) and the associated slum clearance improved the situation somewhat by creating an orbital route from City Road to Whitechapel, and then further south to the Docks and London Bridge, bypassing the City.[9]

Except for the redevelopment of the sites bombed during WWII, and the much more recent wave of new tall buildings creeping northward from the City, the urban armature of Shoreditch has seen little change since the Victorian age. The network has inevitably struggled to cope in terms of capacity and environmental quality in the age of the automobile.

In the 1960s the main streets of our study area (Shoreditch High Street, Old Street and Great Eastern Street), were turned into an intimidating one mile long gyratory system, with sections of up to four lanes of one-way traffic.

[9] For more information on the origins of Shoreditch origins: South Shoreditch conservation area appraisal: https://www.hackney.gov.uk/media/4303/South-Shoreditch-Street-CAA/pdf/south-shoredith-caa



Strategic network in Shoreditch

Despite the good intentions, these arrangements failed to address traffic congestion, and also affected the socio-economic performance of the area prompting a successful campaign to change the layout to the current configuration in 2002.[10] Further adjustments were carried out by Transport for London to improve bicycle permeability, and respond to the ubiquitous presence of bicyclists.[11]

Despite these changes the impact of vehicular traffic remained large in this area, also because of the introduction of the

[10] Source: http://hackney.cc/

[11] Cycling in this part of London is a means of transport as much as a statement and a way of life. Hackney, the local authority responsible for a large proportion of Shoreditch is often referred to as London's Cycle Capital. https://www.standard.co.uk/news/london/hackney-is-top-for-cyclists-with-more-using-bikes-than-car-8474521.html

congestion charge in 2003[12]. The boundary of the toll area in this part of London coincides with the Inner Ring Road including Great Eastern Street and Old Street. As a result, the main arteries are under further pressure as vehicles try to avoid the charge zone during the day. In this sense, its location adjacent to the City in addition to being an economic blessing for the regeneration of Shoreditch, also creates a number of infrastructural challenges.

Away from the main arteries, the network is made up of small streets and tight intersections and is characterised by a complex one-way system that does not, however, discourage drivers and which also has devoted a substantial amount of public space to street parking. The complexities of the Shoreditch context are challenging but nevertheless not dissimilar to those of many other neighbourhoods in London. In a way Shoreditch is typical of other European cities.

Lastly, there is one more and important reason to look at Shoreditch and it is a symbolic one: it is the home of London's start-ups and creative and digital technology scene. So what better testing ground for the possible introduction of CAV technology? If we find a credible solution for CAVs in Shoreditch, then we may have an approach for the whole of London and beyond.

C-Corridors and cells

CAVs will need time to win the battle for space and it could take a generation to decommission manually operated cars. The likely prolonged short-term scenario is one where we will need to fit both types of vehicles on London's streets. This cohabitation is going to be difficult and will limit the options on the table to ensure that CAVs can make a real difference in our cities. Demographic pressure and current infrastructural rigidities will demand bold choices, especially as CAVs will claim street space at the expense of traditional cars without bringing tangible benefits in the short term. How do you switch to CAVs in a constrained place like Shoreditch, then?

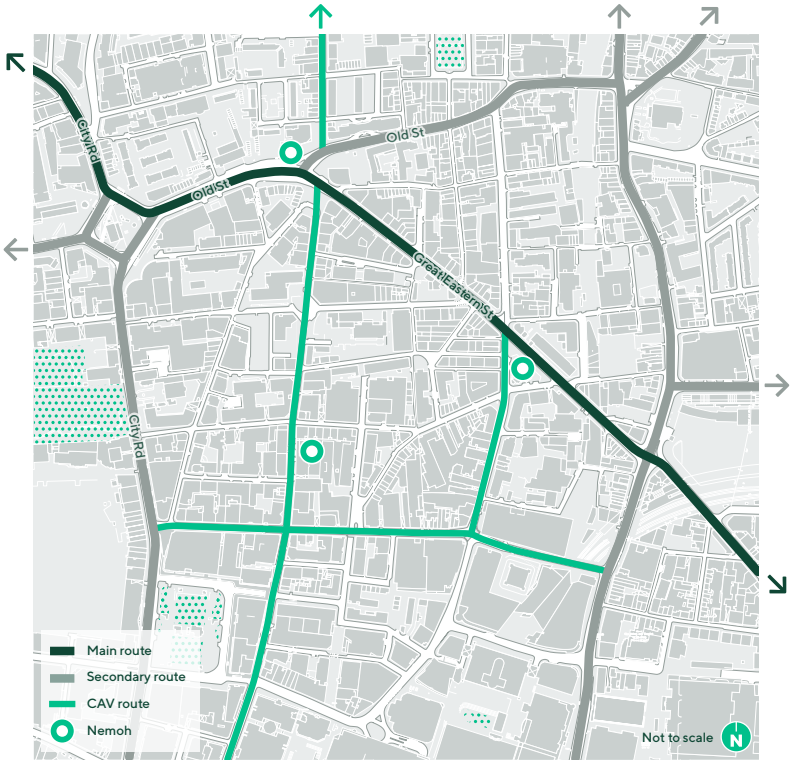
We may be able to create CAVs-only lanes on some sections of the strategic network, however the benefits of CAVs will be minimal, as the bottlenecks on the network would have to mix vehicles frequently. Where CAVs share lanes with buses, the

[12] The congestion charge is a weekday, daytime daily toll charge for vehicles within central areas

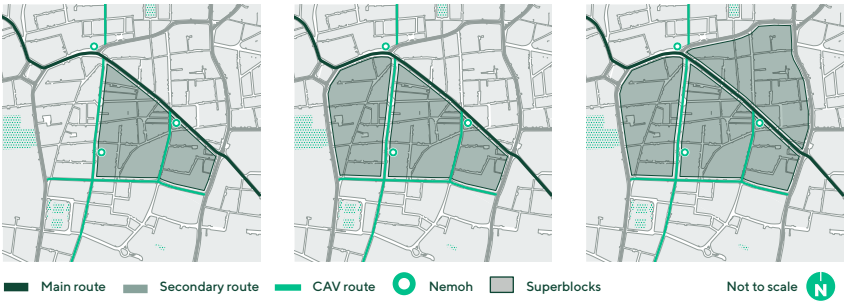
gain in terms of space might also be limited especially if the buses are not driverless and connected (due to the width of lanes and distance that would be required as a separation or buffer from manually driven buses).

The reality is that the strategic network will probably remain substantially unchanged for at least another decade unless its capacity is drastically reduced, which is unlikely. The only noticeable change would be the appearance of CAVs between buses, cars, white vans and bicyclists on the main roads and... more traffic.

We believe the biggest opportunities in the short term will be outside the strategic network. We imagine enabling corridors dedicated to CAVs and bicyclists, especially in inner London, and promoting the switch to CAVs at dedicated stations distributed around the Ring Road. Here long-distance commuters could drop off their cars or switch from mass transport (bus or train) to CAVs, walking or cycling to complete the last mile of their journey.



CAVs would be initially deployed on dedicated corridors, separate from the strategic and the local networks



The C-Corridors define neighbourhoods that will be progressively closed to general traffic and reserved to CAVs. Old cars and public transport will access Shoreditch on the strategic network but converge to Nemohs where traditional vehicles are abandoned to cover the last mile on foot, bike or CAV

These corridors would provide a smooth journey, bypassing the surrounding congestion and promoting the spread of a wider network free from traditional vehicles.

The neighbourhoods 'cells' defined by the corridors will be progressively closed to general vehicular traffic except for CAVs completing routes with origin / destination addresses within the cells. Local streets will then turn into shared surfaces or streets with a very narrow carriageway, from 2 to 4 meters. The rest of the space would be used for cycle infrastructure, additional pedestrian space, blue and green infrastructure, spill out space for businesses and drop-off/services bays for driverless vehicles.

On the C-Corridors and within the 'CAVs cells' we would impose a maximum speed of 15mph, for 2 reasons:

- Safety in case of accidents.
- Getting the priorities right: the more sustainable options are still walking and cycling. CAVs must be more convenient than cars but less than other sustainable means of transport. 15mph is only marginally more the average speed of cyclists in cities.[13]

On local streets, we anticipate a further process of decluttering. Space dedicated for CAVs will be differentiated through the use of different materials, colours, or light. Separation will be avoided so not to repeat the traffic engineering infrastructure frenzy of the 1960s: Londoners have not yet finished sorting out railings, underpasses, and other redundant street furniture

[13] According to Strava https://blog.strava.com/, the average speed per ride in London is 13.9 mph (22.5km/h)

from the streets of London, despite having started the process almost 20 years ago in Kensington HS.

Local streets will see the biggest gains in terms of public realm and sustainability targets. It's the public right-of-way, not the road network, that will experience the most significant gains in space through the retrofitting of former parking spaces for other uses.

As Londoners become more familiar with CAVs and used to interacting with them, the amount of demarcation and traditional street furniture will progressively disappear or evolve. It may still be very useful, for instance, for pedestrians and cyclists to know where to expect to see a CAV, or where the space needs to be kept free for deliveries. Parking will still occur, but less frequently and in a more intelligent (i.e., pre-reserved spaces) flexible manner (e.g., morphing to loading bays when required).

Some locations along the kerbs will support charging facilities, but these will be eventually replaced by induction technology, which may reduce clutter and maintenance costs. Ideally, charging would occur over stretches of roads, while vehicles are in motion, rather than along kerbside where vehicles must be parked over extended periods of time. In any case, the majority of charging will occur in the mobility hubs and in CAVs servicing facilities.

The progressive demise of manually operated cars will be facilitated by creating a series of mobility hubs along the strategic network. This would be achieved by retrofitting existing multi-story parking garages and by building new ones. Secondary hubs will be created in central areas to deal with peak demand. Within a few years people will be able to drive their cars then drop them off at a mobility hub and switch to a shared CAV or bicycle.

The future streets of Shoreditch

How do we imagine Shoreditch evolving following the application of our vision for London in the age of CAVs?[14] We suggest an approach of reconfigurations by street types. However, we are aware that the complexity of London's fabric does require an adaptation of the approach to respond to the infinite number of local idiosyncrasies.

There are no standard streets in Shoreditch, instead we have a full range of typologies from alleys to residential streets, from major arteries to mixed-use local distributors, from shared surfaces to roundabouts. Despite this diversity there are also common denominators, including:

- Streets with limited widths.
- Extremely thin transitional semi-public spaces between the pavement and the entrances to the buildings.
- Insufficient green infrastructure with limited tree planting.
- Infringement of the public space immediately outside local businesses.
- An eclectic mix of buildings both in terms of age and type, defining Shoreditch's character and liveliness.
- The dynamics between buildings and streets influencing the street type and its role within the circulation network.

Strategic network & local distributors

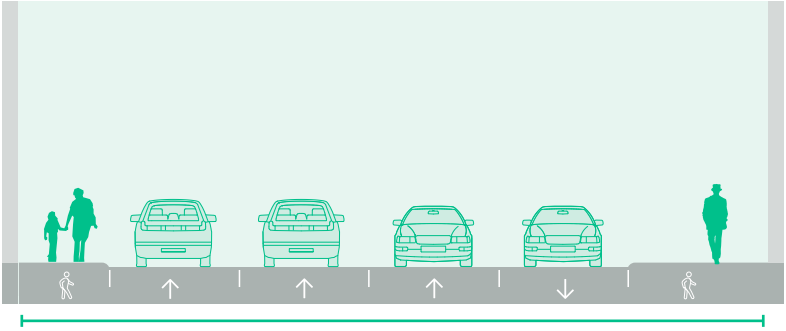
Key routes such as Old Street, Great Eastern Street, and Shoreditch High Street, criss-cross Shoreditch and form part of London's Inner Ring Road. Their widths are as narrow as 16m (Old Street in Hoxton), 17.5m (Great Eastern Street) and 18m (Shoreditch High Street) and allow traffic in two directions, high frequency bus services, a number of pedestrian crossings and traffic lights at short intervals.

In addition to the strategic road network, Shoreditch features local collector roads such as the southern section of City Road, Hackney Road and Bethnal Green Road. The width of these roads are also extremely constrained as, in addition to hosting bus routes without continuous bus lanes, they also support two-way traffic and parallel street parking.

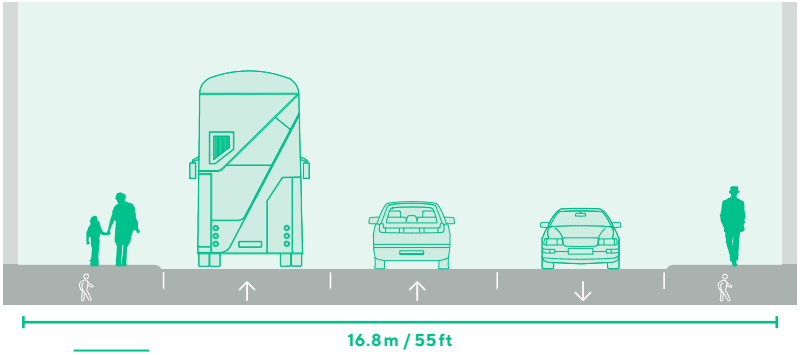
[14] See also in the same direction Hackney Council's Low Emission Neighbourhood Plans here: https://zeroemissionsnetwork.com/len

In the short term, these important streets will broadly remain the same, however incremental change may include the possibility for CAVs to use bus lanes, the creation of a limited number of flexible spaces serving as hodos[15] and reserved loading bays for driverless vehicles. However, we feel that allowing CAVs and buses to share the same lanes on the strategic road network would potentially undermine efficiency of the public transport system, and the latter should continue to be treated as the priority to address traffic and accessibility concerns.

In the medium term, while the strategic road network will remain unchanged, local connectors become bus and CAV only roads. These streets will feature a road of 6 meters (plus 3 meters for cycle lanes), mixing the two types of traffic (buses and CAVs). The roadway could be reduced further to approximately 5 meters if buses are also driverless and would allow a reallocation of space to formal cycle lanes, pavements and shared drop-off areas. At selected locations, the gain of space will allow the introduction of additional trees and loading bays and hodos.

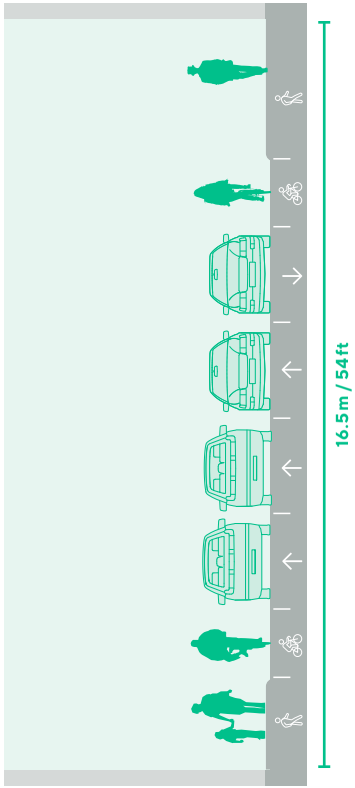


Great Eastern Street, strategic network, existing conditions

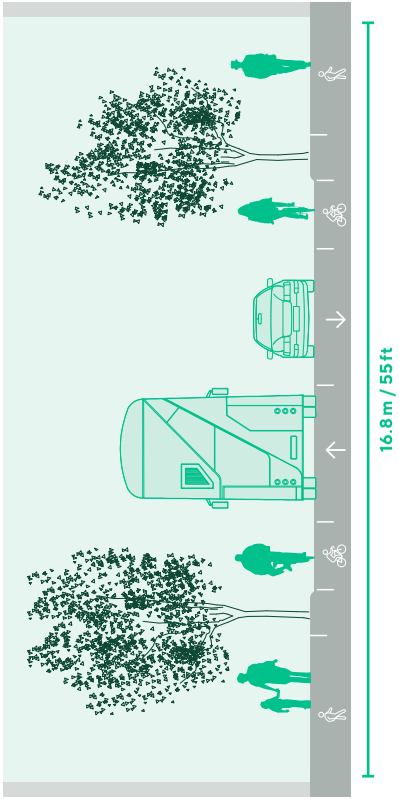


City Road, local connector, existing conditions

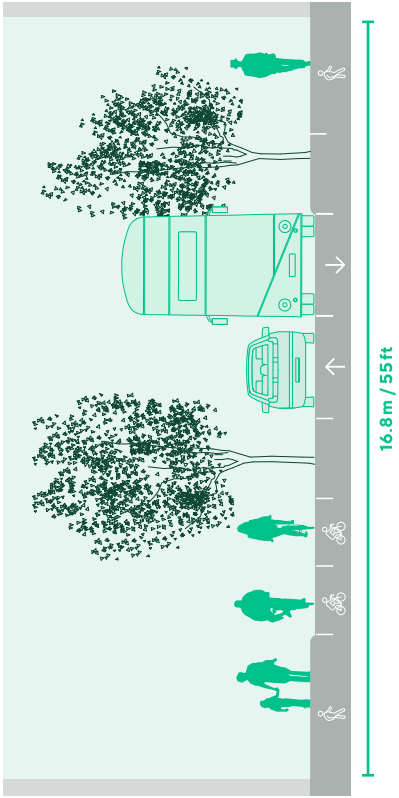
[15] Hodo (is the acronym of hop-on-drop-off), refers to the, that is drop off section of kerb or bays where people and/or goods access CAVs.



Great Eastern Street, strategic network, proposed, long term



City Road, local collector, proposed, medium term



City Road, local collector, proposed, long term

C-Corridors

C-Corridors will link together a series of local roads to create continuous routes off the main vehicular network. The current layout of these streets typically reserve a large proportion of the road space for parking.

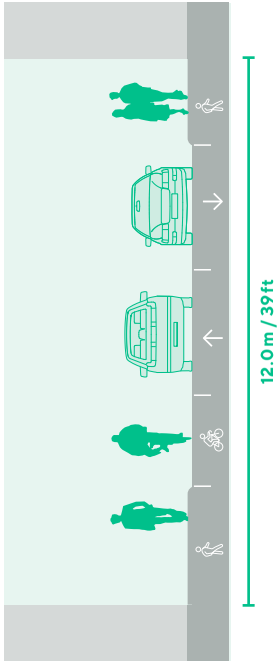
C-Corridors will consist of a narrow roadway (between 3.5 and 4.5 meters, depending on local conditions and overall width of the street and bi-directionality of the street) flanked by a two-way cycle lane (with a minimum width of 2.5 meters). No parking will be generally allowed, however hodos could be arranged on the opposite side, given sufficient street width. Where extra space can be gained, pavement widening, street planting, rain gardens and other types of sustainable urban drainage systems (SUDs) will also be characteristics of the corridors.

Where the C-Corridors meet the rest of the network that is accessible by manually-operated cars, the priority will be given to cyclists and CAVs with stop lines for the side streets. C-Corridors would be clearly defined, especially in the early stages, with specific colours, materials and streetscape treatments for the purpose of both visibility and promotion.

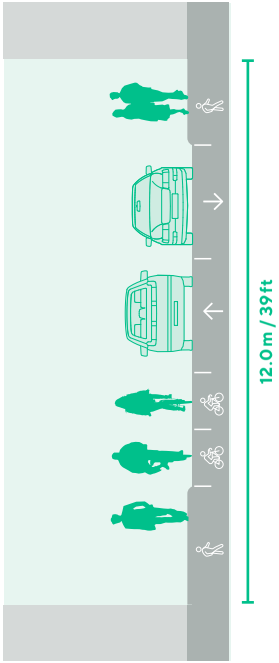
Local streets

Different approaches will apply to local streets, depending on their context (e.g., street width, bordering land uses, frequency of access points, servicing requirements, and so on), however they will have common elements, including:

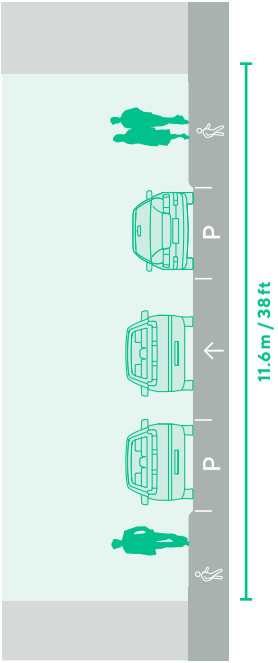
- A complete ban of manually-operated cars. Private vehicles may be stored at dedicated facilities outside the CAVs only zones, or further out at the edges of the city.
- A maximum speed limit of 15 mph.
- Maximisation of opportunities for sustainable urban drainage systems (SUDs) and for planting.
- Frequent hodos, at least one per block to maximise accessibility.
- Conditional access. In other words, only CAVs originating or completing a trip at an address within the local streets network will be able to access them. Only in certain occasions, such as extreme congestion, would the network be open to all CAVs, provided there is a public organisation willing and capable of monitoring and coordinating the traffic flows for the whole network.



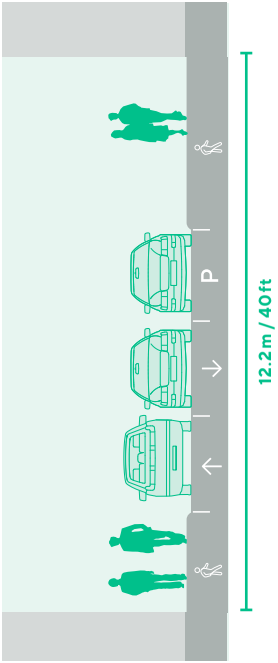
Paul Street, CAVs corridor, current conditions



Paul Street, CAV corridor, proposed reconfiguration



Leonard Street, local street, current conditions

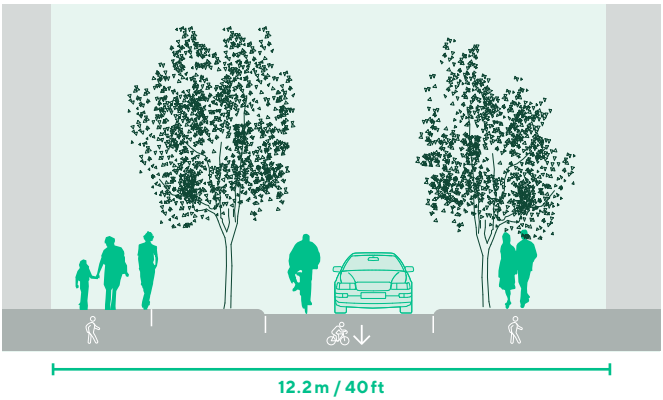


Willow Street, local street, current conditions

- Full accessibility for emergency vehicles.
- Shared use of road space by cyclists and CAVs. The combination of the low allowable speeds of CAVs, their safety credentials, as well as the limited amount of traffic (see previous point) will reduce the potential for conflict and consequently the need for dedicated cycle lanes.

The design variations would include at least three main configurations:

1. Shared surfaces



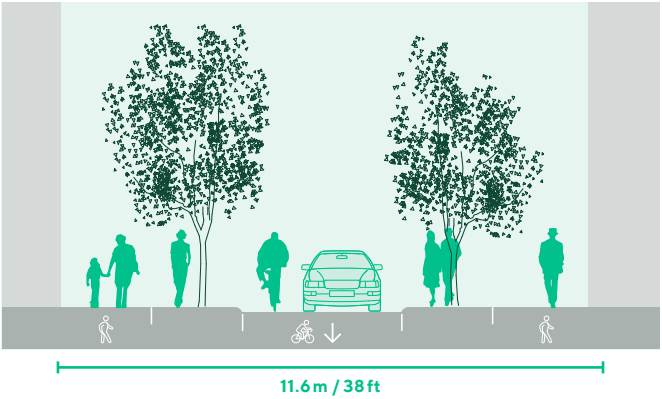
Willow Street proposed

As traditional shared surfaces, there will be no differentiation between pavements and roadways. This type of arrangement would be used in quieter streets, especially residential ones, where CAVs traffic is unlikely to be in conflict with pedestrians and cyclists and even when it does, disruptions to CAVs movement would be deemed acceptable. While a section of 3.5 meters[16] will be used for the circulation of bicycles, CAVs and emergency vehicles, the rest of the street space will be retrofitted as pedestrian space and, importantly, SUDs and other green infrastructure. These green stretches will also be punctuated by hodos and loading and service bays for protracted parking requirements. The number of bays would depend on the land-use mix and local density. In general, bays will not be clustered to minimise their visual impact and to maximise environmental gains of the green stretches as linear ecological corridors. No other parking will be allowed.

[16] At least Additional 0.2m will be required for emergency vehicles, however this can be provided on the pavement along the road space.

2. A 3.5m carriageway for CAVs as well as for cyclists

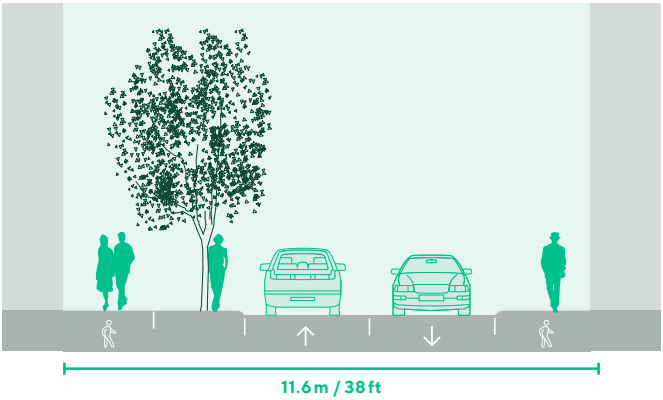
Leonard St, proposed v.A



This would be an appropriate treatment for the narrowest street, with CAVs allowed in one direction only. Provided that CAVs are communicating across different service provider platforms, the one-way street will change the direction of the flow to respond to CAVs routing since vehicles will know if others are already using the street and in which direction. The direction could also respond to the level of traffic congestion during the day. As CAVs are assumed to have a width just below 2m, the extra 1.5 meter is provided for cyclists.[17] In general this would also help to address the requirement of current and future AV emergency vehicles to pass through. The rest of the space would be used, as in the previous case, for green and blue infrastructure, hodos and service bays.

[17] At least 0.2m will be required for emergency vehicles, however this can be provided on the pavement along the road space.

3. A 5.5m carriageway for 2-way CAV traffic as well as cyclists



CAVs will be allowed to overtake slow cyclists only when it is safe to do so (i.e., no CAVs traffic coming from the opposite direction). The rest of the street will be reserved for pedestrians, greening/ SUDs, hodos and loading bays.

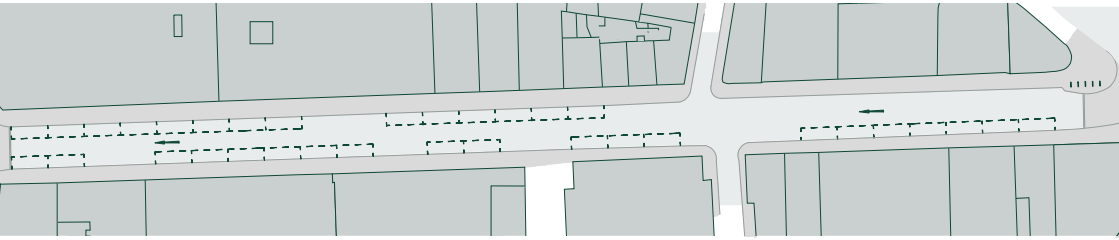
As the greatest opportunities to reallocate space lie in local streets, it is interesting to assess the indicative amenities gained at hand. By amenity gain, we mean space that can be devoted to non-movement functions, such as SUDs, parklets, tree planting, business spill-out spaces, public seating areas and so on. We have tested the intermediate approach and applied it to a 200 meter section of Leonard Street in Shoreditch. The plots fronting the street are typically mixed-use comprised of retail, office and residential uses and have an indicative plot area ratio of 2.5. These are common conditions in London with many high streets featuring similar characteristics.

According to our simulation we may be able to reclaim up to a quarter of the street space (building line to building line) for public amenities. This would be equivalent to an area of around 600 square meters[18] featuring 40 trees. If applied to all local

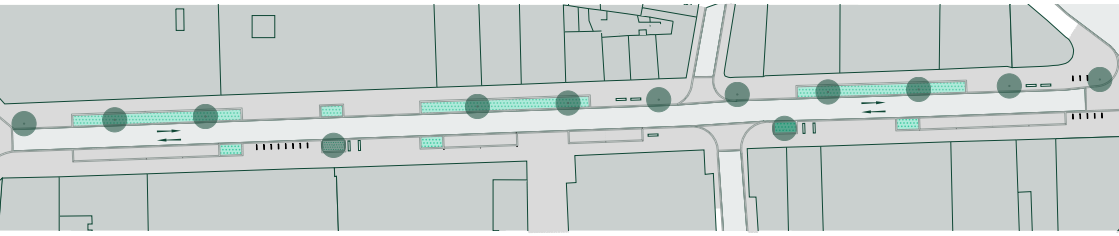
[18] To establish the amount of amenity space we calculated the trips generated by the current land uses on Leonard Street (derived from the TRICs database, 33 one way trips and 9 servicing bays). We then assumed a notional 20% increase in demand to anticipate a potential increase of trips reflecting the increase accessibility of vehicles (e.g. the disabled, teenagers and the elderly), which brought the peak-time hours' demand to 40 trips. We then set the hourly capacity of each CAV hop-on-drop-off bay at 15 vehicles per hour, obtaining the result of 3 dedicated spaces plus 9 servicing priority bays, which could also be accessible to CAVs if not in use. This would bring the total to 12 spaces. Compared to the current on-street provision (34 spaces), this is a third of the previous requirements.

streets in our Shoreditch study area, this could mean creating an urban forest of approximately 1,200–1,300 mature trees and an overall provision of green space (or other amenity space) equivalent to 4 soccer fields.

Despite the number of idiosyncrasies, caveats and assumptions affecting our calculations,[19] we believe the results are encouraging. While CAVs won't transform urban streets into bucolic country lanes, our initial assessment suggests the opportunity for a possible dramatic improvement of London's credentials in terms of sustainability, microclimate and overall livability.



Existing



Proposed

Reallocating space on Leonard Street, Shoreditch

[19] The limitations of our exercise relate to the specificity of the London context in terms of modal share and user preferences, but it also assumes:

- No behavioural changes following the introduction of CAVs;
- An even distribution of trips within the hours (the granularity of peak time forecast data is hourly);
- Each trip rate is limited to same land use in town centre and neighbourhood centre locations;
- Modal split based on Census 2011 Travel to Work data;
- Waste generation use to calculate servicing needs is based on professional judgement and latest policy;
- The average time CAVs occupy the drop-off point is 3 minutes. This seems a reasonable time considering current trends in taxis and car share services which have a tolerance of 3 to 5 minutes before charging for the waiting time. Longer time would imply higher charges therefore discouraging longer use of the hodos;
- CAVs and service vehicle would continue to require bays of 6x2 meters; and,
- CAVs are not private but operate as a MaaS.

Street type relationships

As we propose to create a multi layered network, it will be important to address the issues relating to the interface between different types of roads. This is particularly relevant for pedestrians and cyclists, to help them understand the environment they are navigating, but also for car drivers to clearly understand which areas they are accessing and if they are allowed.

Both C-Corridors and car-free neighbourhoods could feature threshold treatments. However, we don't advocate dramatic colour schemes such as the ones delivered for the London Cycle Superhighways. We do believe that it would be important to showcase the corridors and promote them, but also that this should be sympathetic of the context. Enforcement against manually operated cars entering restricted zones could take place via electronic thresholds and subtle road signs to warn drivers. The entry points could feature roadway narrowings and, where possible, small public spaces. Also, there will be a clear opportunity for a dedicated vertical and horizontal wayfinding system associated with the CAVs network.

As C-Corridors will become priority routes in the short and medium term, there will also be opportunities to stress their status in terms of special streetscape details. Finally, these streets should feature continuous pedestrian pathways along their whole lengths and possibly bespoke lighting. At street junctions within the CAVs-only network, additional setbacks could be required at corner buildings, especially where these are used by pubs, bars, restaurants or cafés, so to create spill-out spaces supporting street level activity.

New technology new buildings

Shoreditch's streetscape is not the only visible change prompted by CAVs, as the new vehicles will be accompanied by a new pseudo mobility hub, or Ne-mo-hs. These will take some of the spatial arrangements of familiar transport infrastructure types, like train stations and parking garages, but ultimately result in a different types and variations of streetscapes depending on their location.

In fact, Nemohs will be of three main types:

1

Major hubs

The hubs along the strategic road network will inevitably be busier and larger as they will promote the change from private vehicles or public transport to CAVs. Where possible these will be integrated with existing underground and train stations to maximise their potentials. They will have a prominent street frontage and integrate retail and leisure opportunities targeting the users. Click and collect services will be available and eventually offer the possibility to pre-load CAVs with goods ordered by the single user. For this reason, hubs will include small logistics centres to unpack deliveries for the last mile. Illustrative cases for Shoreditch would be Old Street Roundabout and especially the Bishopsgate Goodsyard at Shoreditch High Street Station.

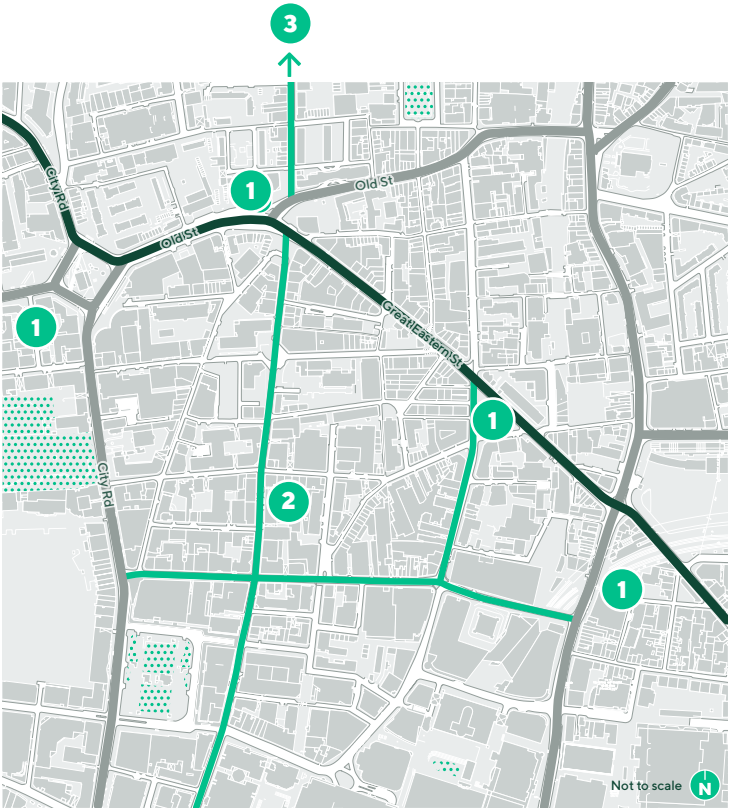
The structures will provide storage space with charging facilities and servicing for CAVs as well as short-term (generally one day maximum) parking spaces for traditional cars. They will also integrate cycle storage and a cycle surgery.

Surviving filling stations in the city such as those on City Road and Old Street are obvious candidates for redevelopment to accommodate these hubs. Over time, as manually operated cars decrease in numbers, more and more space in the hubs will be reallocated in favour of CAVs.

2

Neighbourhood hubs

A second type of Nemohs will be located near C-Corridors to balance the load on the CAV network and to respond to peaks in demand, particularly near the city where the fluctuation of demand will be more pronounced. The creation of some of these facilities will be opportunistic, for instance achieved by



Nemoh's hierarchy with illustrative locations

retrofitting an existing multistory parking garage on Paul St, while others will be new planned facilities on available plots, or more likely plot redevelopments, which are likely to combine a mix of land uses, such as residential and office and retail, to improve viability.

These hubs will be smaller and have less presence on the street with minimal street frontage as most of the CAVs hosted will leave the structure to reach clients elsewhere.

3

Remote hubs

This type of Nemohs will be entirely devoted to storage and servicing, therefore won't necessarily have a presence on the street. They will provide reserve capacity for CAVs to respond to peak demand for parking and idling and optimise distribution of CAVs on the network.

In the long term, as C-Corridors and car-free neighbourhoods will spread to the edges of the city, the remote hubs near main arteries connecting London with the rest of the country (e.g., Potters Bar and Waltham Cross), will morph into interchange stations that will intercept long distance drivers switching to CAVs to complete their journey to Shoreditch or central London.

Further implications for the built form

CAVs will trigger the emergence of new types of facility but also promote changes in established typologies. Space-intensive functions such as service yards will become more efficient and require less space as CAVs are able to manoeuvre more effectively. The need for plots for car parking will largely disappear, to the delight of developers who will not longer need to build expensive parking garages and could use the space for more profitable functions.

Parking policies will change dramatically:

- Parking minimums will be replaced by maximums.
- Maximum parking ratios will relate to the amount of kerbspace allowed for drop-off or hodos sise.
- On plot drop-off areas will be the exception rather than the rule.
- Hodos would be charged by use to recover some of the municipal revenue losses from parking fees and tickets.

As on-site parking garages and service yards disappear or shrink, buildings will increasingly have less 'back of the house' space and more and more usable frontage. The relationship between public space and the private sections of the buildings will improve and the importance of lobbies and transition areas will increase, as it is already happening for business reasons in Shoreditch. Here local studios as well as shops have started a well-established process of blending of functions and spaces promoting the creation of a diffuse semi-public space at the ground floor, public pavements and small yards, with coffee shops and bars becoming retail spaces and meeting rooms.

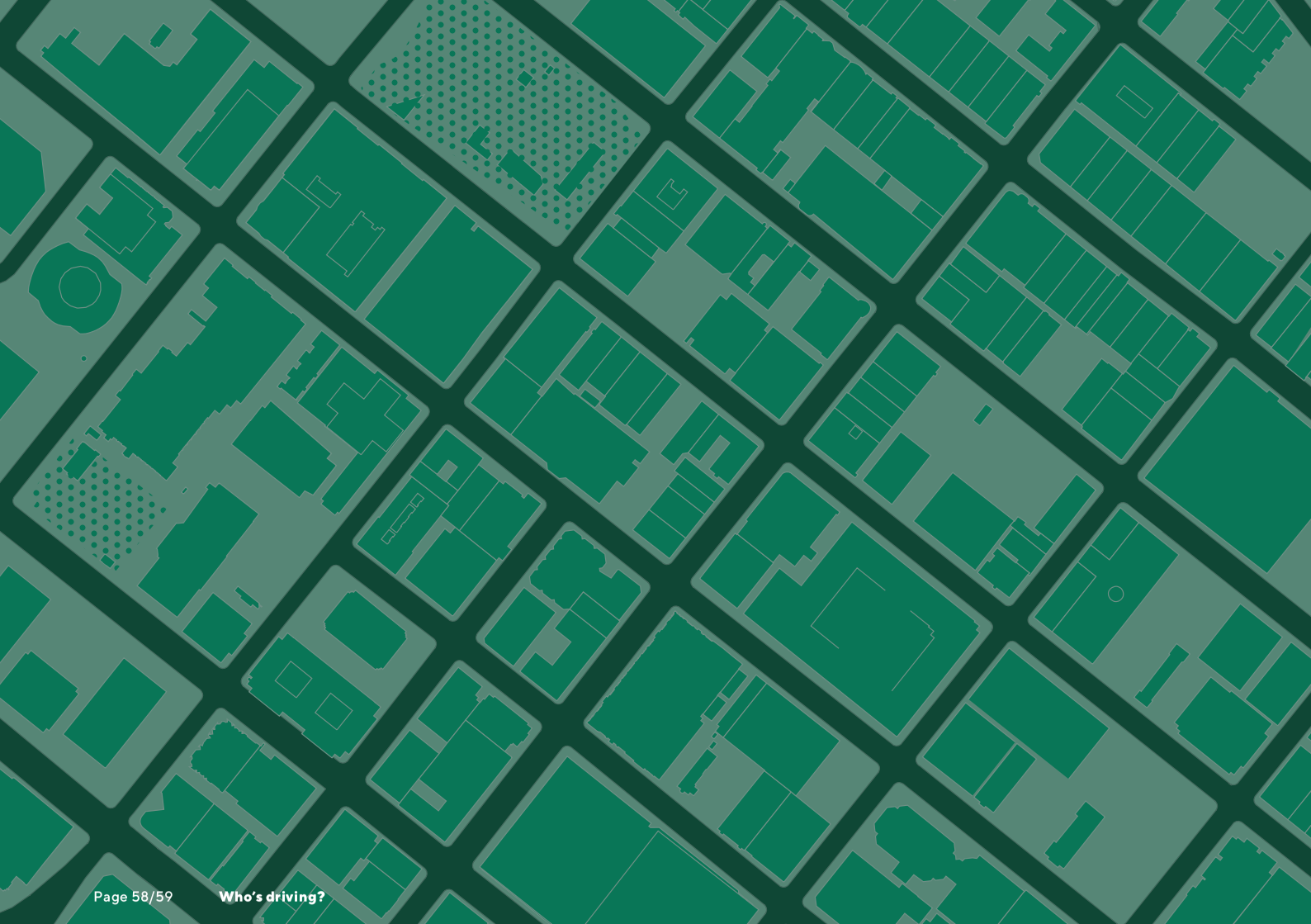
As CAVs make more street space available in quieter, less polluted and attractive local streets and improve the relationship between streets and buildings with the reduction of sterile frontage devoted to service areas, we will see further incentives for business to spill-out onto the public realm, boosting street life.

The appearance and progressive rise of CAVs will stimulate the final stages of Shoreditch densification, as the last remaining surface parking garages and gas stations will become development sites.

In the next 20 years Shoreditch will still be characterised by the buzz and traffic of its three busiest thoroughfares defining the 'Triangle', but outside these main roads the area has the potential to become a green neighbourhood taken over by pedestrians, cyclists and, along well-defined corridors, CAVs. Extra spaces on smaller streets will allow ground floor uses to spill out. The substantial increase in amenities will make this part of London even more desirable for both residential and commercial uses and, unless the same logic is quickly applied to other areas of London undergoing similar transformations to their environmental conditions and attractiveness, it will accelerate even further the gentrification processes at the eastern edge of the City.

Greening and public realm improvements will be a common thread that will respond and adapt to the individual character of each street and building on a wide palette of interventions.

Environmental improvements will create a green network which radically changes the ecological performance of the neighbourhood in terms of drainage, air quality, amenity and biodiversity.



LOS ANGELES

"Come to Los Angeles! The sun shines bright, the beaches are wide and inviting, and the orange groves stretch as far as the eye can see. There are jobs a-plenty, and land is cheap. Every working man can have his own house (and his on car), and inside every house, a happy, all-American family ... Life is good in Los Angeles ... It's paradise on Earth."

– Tabloid journalist Sid Hudgens in the film *L.A. Confidential* (1997)

Context

With the revolution of the private automobile after World War I and II, Los Angeles witnessed a rapid and unprecedented transformation that is still underway. At the turn of the 20th century, the city was a relatively small and peripheral centre within the USA and counted a population of approximately 100,000 people within the original 28 square miles.[1][2]

The first gasoline-powered vehicle appeared on the streets of Los Angeles in 1897.[3] In 1932 the city had grown to 450 square miles. In 1950 the population had grown to almost 2 million.

Today, the City of Los Angeles has a population of over 4 million for an area of 472 square miles while the Los Angeles County counts for over 10 million people for an area of 4,084 square miles.[4][5] The Los Angeles-Long Beach-Anaheim, Metro Area is the 2nd largest metropolitan area in the nation with a combined population of 13.3 million people for an area of 34,135 square miles.[6] In 2025 the greater LA area will be the densest urban area in the US with an estimated 6,450 people per square mile and a projected total population of nearly 15.7 million.[7]

According to the Southern California Association of Governments (SCAG), 90% of the daily commuter trip in the region are currently made by private automobile.[8]

Lewis Mumford called Los Angeles the 'reductio ad absurdum' of the cult of the car, a city hijacked by the false promises of the motor age.[9] Apart from Detroit, there's no American city more identified with the automobile than Los Angeles. Automobiles are part of the city's milieu. Movies like Crash (2005), or the recently award winning *LA LA Land* (2016), the work of contemporary local artists like Carlos Almaraz and David

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1 For a short history of Los Angeles see: https://www.britannica.com/place/Los-Angeles-California/Cultural-life#toc260687

2 See U.S. Census Bureau data for population growth at: https://www.census.gov/quickfacts/fact/table/losangelescitycalifornia/PST045216

3 According to the LA Almanac: http://www.laalmanac.com/transport/tr10.php

4 http://www.latimes.com/local/lanow/la-me-historic-population-20170501-htmlstory.html

5 https://www.discoverlosangeles.com/press-releases/facts-about-los-angeles

6 https://datausa.io/profile/geo/los-angeles-long-beach-anaheim-ca-metro-area/

7 According to Bloomberg: https://www.bloomberg.com/graphics/best-and-worst/most-crowded-in-2025-global-cities-1/

8 In this regard see SCAG's 2016-2040 Regional Transportation Plan at: http://scagrtpscs.net/SiteAssets/ExecutiveSummary/index.html

9 See Lewis Mumford. The City in History 1961, p. 510

Hockney to cite a few, all testify how car-culture has become part of the city's genetic order, its DNA; an auto-oriented landscape for an auto-oriented population.[10]

In the last 20 years, the region has made relatively modest progresses in addressing modernist mistakes of car-led city planning, in dismantling barriers that were created by making traffic efficiency the driving force, and in desegregating uses. Even today, re-configuring streets and urban freeways, or at least some of them, is considered infeasible or approached with extreme caution, while in other US cities – like San Francisco, New York City, Boston, or even Dallas, to cite a few examples, successful projects of this types have been carried out for years.

Complete Streets and Vision Zero efforts have received fiery push-backs because of this car-led planning culture. The recently adopted Measure M, a ballot measure to fund transportation projects in the LA County, is still pro-car measure for the most part, even if it will foster the development of alternatives to the automobile.[11] One of the most innovative documents recently released by the city, Urban Mobility in the Digital Age, provides a roadmap for the city's transportation future. The report, addresses the city's plan to combine self-driving vehicles with on-demand sharing services to create a suite of smarter, more efficient transport options.[12] Still, substantial efforts remain to be undertaken to make this vision a reality and to establish a reliable multimodal transportation system for the region and avoiding complete gridlock.

This condition of almost total dependency on the automobile for urban mobility is fairly typical within the context of US cities, with perhaps Los Angeles and Houston among the primary examples of car-centric urbanism worldwide!

One of the much-presaged benefits of the CAVs revolution will be more efficient traffic operations leading to increased carrying-capacity of existing road infrastructure and less parking requirements, with the potential to reallocate road and parking space away from vehicles to other uses.[13] With

[10] Michael Manville and Donald Shoup. Parking, People, and Cities. 234 / Journal of Urban Planning and Development. December 2005.

[11] See METRO's plans for Measure M at: http://theplan.metro.net/http://theplan.metro.net/

[12] https://la.curbed.com/2016/9/9/12824240/self-driving-cars-plan-los-angeles See the report at: http://www.urbanmobilityla.com/strategy/

[13] See in this direction the recent work by NACTO at: https://nacto.org/publication/bau/automated-vehicles-future-city-streets/

the ever-increasing levels of traffic congestion that the Los Angeles urban region is experiencing and, according to SCAG, will increasingly experience in the coming years because of population's growth,[14] there will be a temptation to simply use the space 'gained' to accommodate more vehicles.

City makers could instead take this opportunity to instigate a paradigm shift and break the cycle of automobile dominance on Los Angeles streets. They could champion the reallocation of any space away from motorised vehicles to more productive and resilient uses, people and human-scale activities, and finally break the perpetual circle of traffic-induced demand. The CAVs revolution is a great opportunity to use this 'extra space' to retrofit the urban region in a more climate, context-conscious and sustainable way.

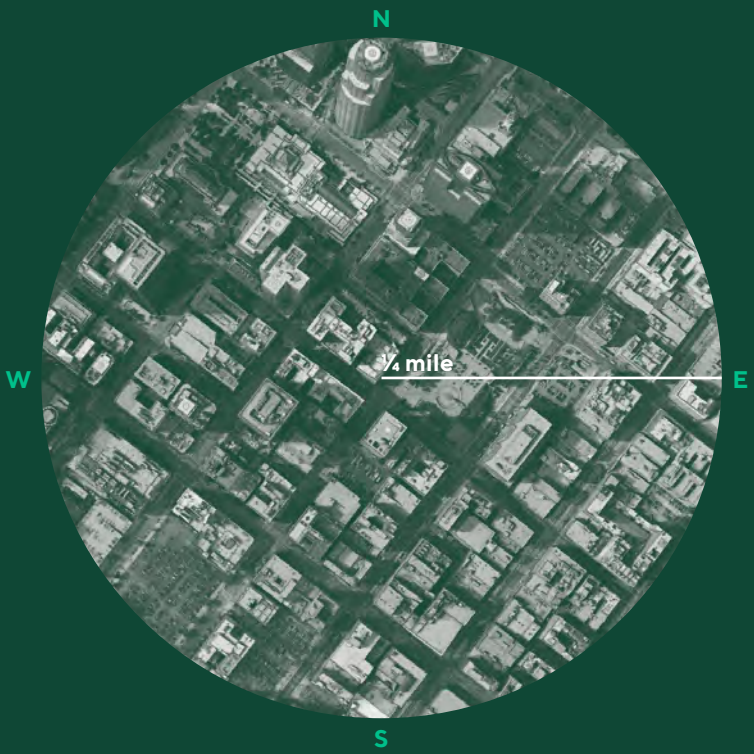
With the advent of CAVs, planners and stakeholders involved in city making will have the once-in-a-lifetime opportunity to re-consider how Los Angeles streets function as part of a movement network. To introduce a hierarchy to an historically undifferentiated (to other than cars) gridiron plan; a multi-layered network approach at different scales to create connected routes for all modes. This will entail identifying strategic routes for CAVs, Bus Rapid Transit Systems, Light Rail Transit and streetcars, manually operated vehicles, buses, and bicycles, and not necessarily all on the same streets. In some streets, automated buses and CAVs may be prioritised, in other pedestrians and bicycles may be prioritised with minimal or no CAVs, or other vehicles allowed at all. One of the best expression of a layered network approach to city movement planning today is the macro-block.[15]

CAVs will most likely constitute a mix of shared service and private ownership. Private CAVs would progressively be banned from accessing urban cores within the region as private ownership will only promulgate the congestion and vehicle dominance that we see in Los Angeles today. In the future, only CAV-shared type of uses would be allowed access to city centres so to promote multimodal and pedestrian-first environments. Could the downtowns of Los Angeles, Santa Monica, Pasadena, Long Beach or Burbank be reorganised in such way?

[14] http://scagrtpscs.net/SiteAssets/ExecutiveSummary/index.html

[15] We can see an informative experiment these days in Barcelona – the superblock: https://www.theguardian.com/cities/2016/may/17/superblocks-rescue-barcelona-spain-plan-give-streets-back-residents

Los Angeles



Location of study area in Downtown Los Angeles

Figueroa St
600 S
RANGE ROVER


NOW OPEN!
SPEED LIMIT 25
TAXI
first mile

Downtown Los Angeles

To showcase the possibilities of this approach we have selected a ½ mile square area of the Financial District in Downtown Los Angeles (DTLA) and applied the principles presented earlier.

As clearly evidenced by the 1970 famous and still relevant plan 'Concept Los Angeles: The Concept for the Los Angeles General Plan',[16] we can understand the urban region as a stellar system of multiple centres, or cores, connected in different capacities through major corridors, with DTLA being the main core within the region. The ideas here presented could be applicable to the other cores as well.

Downtown Los Angeles's Financial District presents the typical undifferentiated grid pattern of streets and blocks that are common to almost every city's core in United States. The grid plan, since its first use in 1682 as the physical foundation for Philadelphia by William Penn,[17] has been used extensively as a structural framework in a number of American cities in every one of the 50 states.

The typical DTLA block size measures about 350 by 550 feet and the typical street section varies from 80 to 90 feet. By contrast, the smaller New York City blocks in Midtown Manhattan measures 400 by 200 feet and have a typical street section of 60 feet. These are potentially good dimensions for a walkable environment. Even with the substantial improvements of the last years, thanks to massive private real estate investments and the injection of more than 60-thousands new residents,[18] years of car-driven policies and car-driven mind-sets, shaped and still shape the unpleasant urban experience in Downtown. A one-way street system is ensuring a fast (?) moving vehicular traffic to access freeways and over dimensioned parking standards and perceived market demands are producing an over abundance of on-street and off-street parking spaces.[19]

According to a report published in the Journal of the American Planning Association from 2010, 14% of the 200 square miles LA County's incorporated land are dedicated to parking

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[16] See regarding this pivot vision plan for Los Angles a recent article by Planetisen: https://www.planetizen.com/node/23535

[17] https://www.theguardian.com/cities/2016/mar/22/story-of-cities-7-philadelphia-grid-pennsylvania-william-penn-america-urban-dream

[18] https://www.downtownla.com/images/BID_AR17_ALL_Web_v4.pdf

[19] See regarding this topic an interesting article by Citylab at: https://www.citylab.com/solutions/2015/01/just-because-you-cant-find-a-place-to-park-doesnt-mean-there-arent-way-too-many-parking-spots/384509/

infrastructure, for a total of 18.6 million parking spaces. These break down into 3.6 million on-street and 15 million off-street, or about 3.3 parking spaces for every car, with about a third of the off-street spaces being residential. Downtown is home to the greatest parking density, with some census tracts in the central business district with upwards of 260,000 total off-street parking spaces per square mile, mostly packed into multi-level garages.[20]

We can assume that at least 70% of a typical DTLA street is dedicated to the needs of cars, and that based on a study by Manville and Shoup,[21] more than 50% of DTLA area is dedicated to streets and to on and off-street parking. Of the approximately 3,000 acres of land in DTLA, we can then assume than that more than 1,000 acres are dedicated to car uses. These numbers give a sense of the potential that the CAVs revolution could unlock in terms of recapturing these spaces for higher and better uses.

CAVs super grid

The CAVs revolution will give the opportunity to radically rethink the street hierarchy of urban cores, like DTLA, in terms of movement and place. This is due mainly to the abundance of available space and to the redundant property of the grid system, qualities that are not present in other contexts like London.

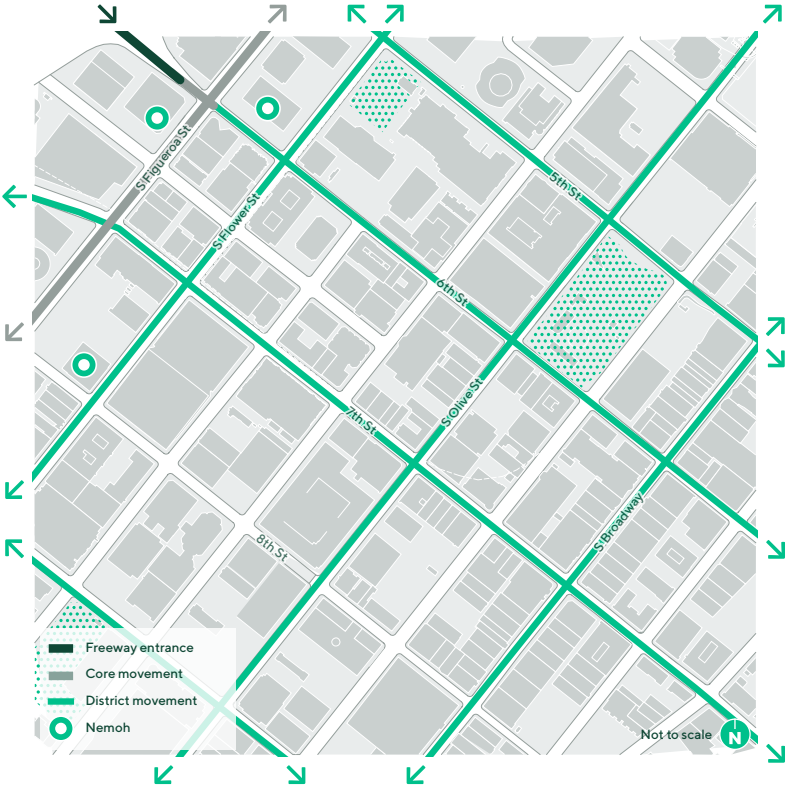
We can then imagine how in the not too distant future urban cores like DTLA could be reshaped.

The following diagrams show our proposed, long-term new four-level hierarchy for vehicular movement imposed over today's undifferentiated street grid: multiway urban boulevard; core movement; district movement; and local movement streets.

Urban freeways cutting through urban cores, like the 110 FWY in the diagram, will be progressively decked over or reconfigured into multiway urban boulevards with dedicated mass transport space thanks to CAVs efficiency and increased real estate value. This will help reconnect and revitalise adjacent urban fabrics and regain a more human scale within the core, while carrying more people faster and in the same

[20] See complete report at: http://www.transportationlca.org/losangelesparking/

[21] Michael Manville and Donald Shoup. Parking, People, and Cities. 234 / Journal of Urban Planning and Development. December 2005.



District movement grid

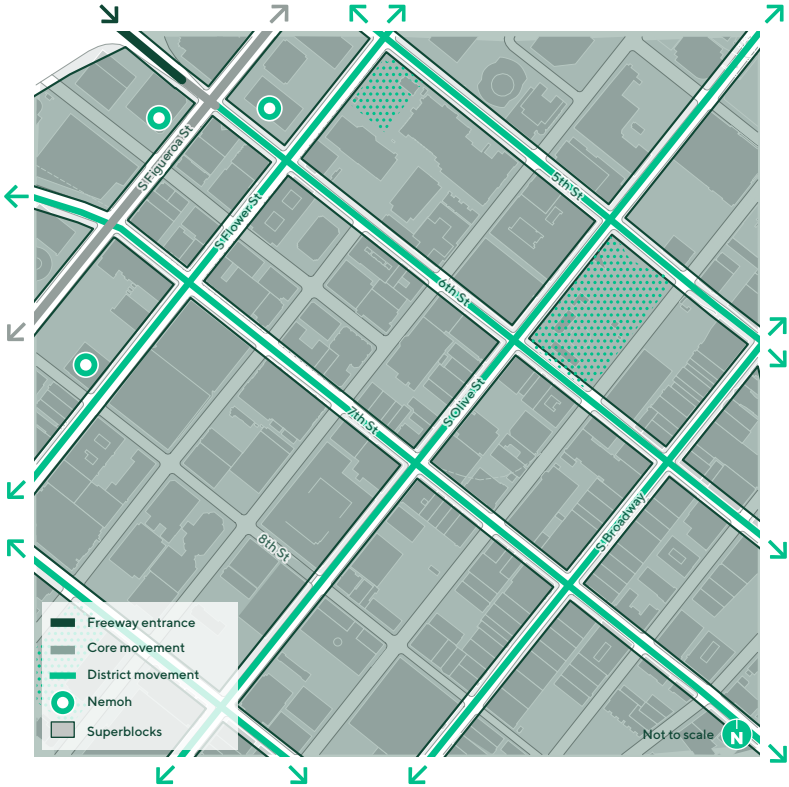
space or less. Core movement streets will define the different districts within the core; district movement streets will define superblocks within districts; and local movement streets will provide fine grain accesses and services to single properties.

As CAVs becomes the majority of vehicles on the streets and reach level 5 – full automation,[22] probably by 2040s in Los Angeles,[23] urban cores would be made progressively accessible only to shared – public or private CAVs systems, while manually operated automobiles would be altogether banned from accessing them.

Real-time congestion charges could regulate the amount

[22] See NHTSA for latest market predictions at: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

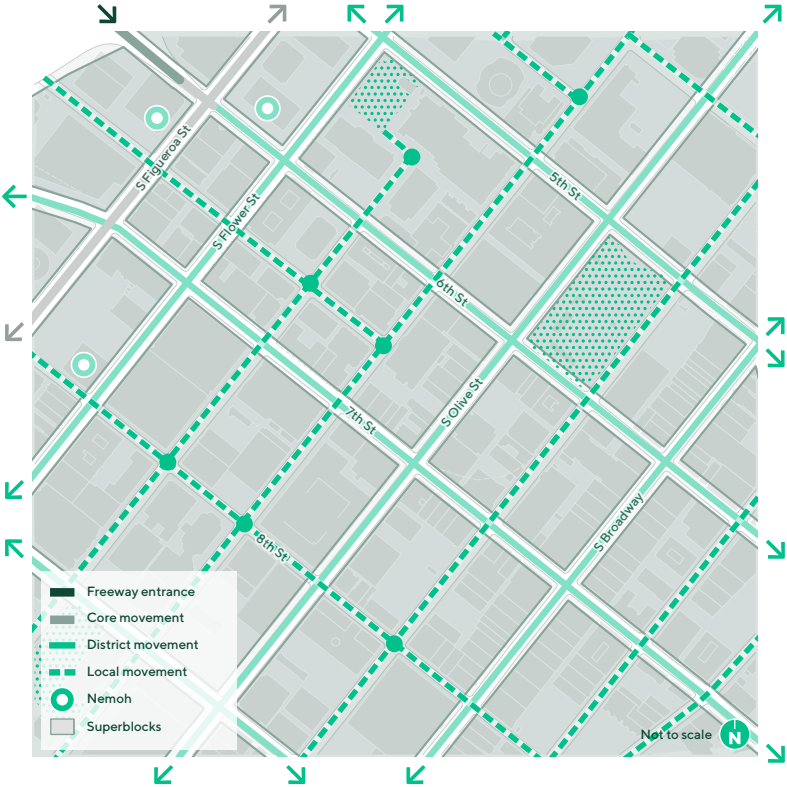
[23] https://www.ieee.org/about/news/2012/5september_2_2012.html



District movement grid

of privately owned CAVs reaching cores using the system of freeways/multiway urban boulevards. If used, privately owned CAVs will have the option to drop off/pick up owners in dedicated mobility hubs at the periphery of the core along the multiway urban boulevards and then self-park in remote, less valuable locations. From mobility hubs, passengers will have to shift to a shared CAVs system, use transit, bike, or walk, to reach their final destination in the core. Despite the politically difficulties, private CAVs movement will eventually be permitted only on core movement streets to access mobility hubs. Eventually, these hubs will also accommodate taxi drone types of services for core-to-core and hub-to-hub passenger mobility.

The maximum speed allowed within the core for all vehicles will be 25 mph. District movement streets maximum speed will be 15 to 25 mph, and for local movement streets will be 15 mph. Even if CAVs will drastically reduce the risk of crashes and



Local movement grid

injuries by up to 90%,[24] these limits will keep speeds down to a safe level for all users while improving the quality of life on the street. Lower speeds in fact reduce community fragmentation caused by high speeds in districts and neighbourhoods,[25] and ultimately considerably improve the sociability of places.

District movement streets will accommodate CAVs mass transport and shared CAVs system services and connect the different districts. All streets will be re-converted to a two-way system.

[24] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world

[25] On on this topic see also the work by Joshua Hart. "Driven to Excess: A Study of Motor Vehicle Impacts on Three Streets in Bristol UK"

New + existing open space network

District movement streets will define the super blocks. Dimension and configuration of each super block may defer, depending on local constraints and land uses, but will generally define a specific sub-district and pedestrian first zone, and will foster a particular 'neighbourhood identity'.

Local movement streets will have a maximum speed limit of 15 mph. Shared CAVs will be permitted access only if the origin or destination of the trip's address is on the street.

The re-organisation of downtown's grid in district movement streets and super blocks will optimise vehicular movement and, by redesigning street sections, allow the introduction of an active grid layer (yellow in the diagram above) on the local movement streets. The active grid will connect super blocks in central areas with existing and new provisions of open and green spaces. The active grid is thought of as a movement

& place system for walking, biking and rolling, but also as a green/blue infrastructure for environmental sustainability, and as a linear system of open spaces and urban parks for public enjoyment and sociability. The active grid will be a capillary system and serve all areas within the core.

Urban streets are public spaces. Streets intersections are primary public spaces. The efficiency of the new CAVs super grid system, by reducing the space needed for vehicular movement and parking, will permit the re-design of intersections as meaningful public spaces for people, add to the city's offer of amenities and improve the overall quality of the urban experience. Local streets intersections in the middle of super blocks will be redesigned to become plazas, squares, or pocket parks, and will be the centre of super blocks' social interaction.

Downtown Los Angeles has currently about 500 city blocks. Assuming a future configuration of approximately 125 super blocks and 125 local intersections, each occupying an area of 10 to 15,000 square foot, for a total of about 36 acres; with half of this space reclaimed as public space, DTLA could incrementally add about 18 acres of public and green spaces simply by reconfiguring these types of intersection.

A resilient urban from

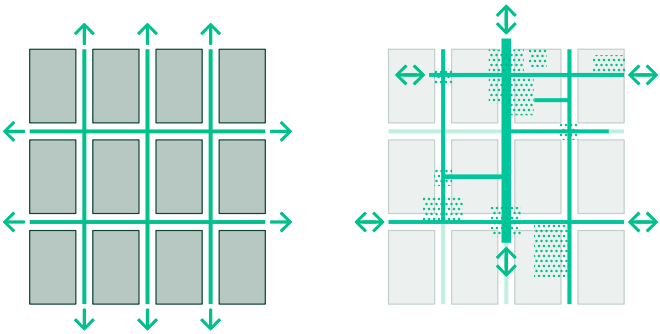
The CAVs super grid strategy will also be an opportunity to retrofit urban cores so to be more sustainable and resilient. Assuming that in urban cores CAVs will be almost exclusively of the shared use and multiple occupancy type, according to our latest market predictions,[26] we could imagine how by 2040, more than 50% of the current parking spaces existing today in DTLA could be redundant. Considering only surface parking – on street and parking lots – this will correspond to a total surface area of 800 acres or more, the size of Central Park in New York City!

Taking advantage of this vast public and private space re-gained from cars use, the active grid could be paired by a new system of parks, or patches, connected through ecological corridors to the existing green areas and to the larger rural corridors. This will allow an urban core like DTLA to gain new ecological benefits by facilitating natural flows and movements

[26] For more details on Steer Davie Gleave's study on CAVs future parking demand see https://home.kpmg.com/xx/en/home/insights/2017/07/parking-demand-in-the-autonomous-vehicle-era.html

across the city[27] and improve its climatic resiliency. It will also be an opportunity to provide DTLA with a mix of urban parks, green areas and vegetable gardens as civic amenities which is almost completely absent today, and that are an important piece in the construction of 'social infrastructure' which is critical in the competitiveness agenda of cities worldwide.[28]

The system of parks will allow the protection of potential aquifers, support biodiversity, provide stepping-stones for species and use as a system of hydrological sponges against flooding. Ideally, these parks will have a minimum dimension of 9 acres – about 2 DTLA blocks or more – and will be placed at no more than ½ mile or 10 a minute walk from one another.



Urban grid vs ecological grid

[27] See on this topic the seminal work by Richard T. T. Forman in Urban Regions: Ecology and Planning Beyond the City. 2008

[28] For more details regarding the competitiveness agenda for cities see for instance the report by The World Economic Forum 'The Competitiveness of Cities' at: http://www3.weforum.org/docs/GAC/2014/WEF_GAC_CompetitivenessOfCities_Report_2014.pdf

A system of connected medium and large parks

This configuration would maximise the combined cooling capacity of the system over the core and help reduce the heat island effect of the surrounding environment, an issue that will only intensify in DTLA in the coming years.

To understand the cooling potential of urban parks to contrast the heat island effect, it is helpful to look at the research done over urban climate on Tiergarten Park in Berlin by Stulpnagel, Horbert, and Sukopp. The study concludes that the larger the park, the greater the temperature difference compared to the built-up surroundings.[29]

A passive energy strategy of this type could bring a noticeable temperature reduction to the surrounding areas. A 10-minute walk distance between parks will also ensure everyone living or working in downtown has access to meaningful greenery within a 5-minute walk.

Space in the parks could also be allocated to contribute to the protection of water quality and quantity of the urban watershed. Designed stormwater ponds, for example, could be used to control large volumes of water. In the design of this system of parks, each park site should be understood in terms of its relation to its watershed and other possible water sources. Ideally, to accommodate ecological concerns and to provide valuable program for the city, parks could be 'split' into two main areas: one more 'naturalise', where most of the ecological issues can be addressed, and one more heavily programmed to address the required uses for the local population.

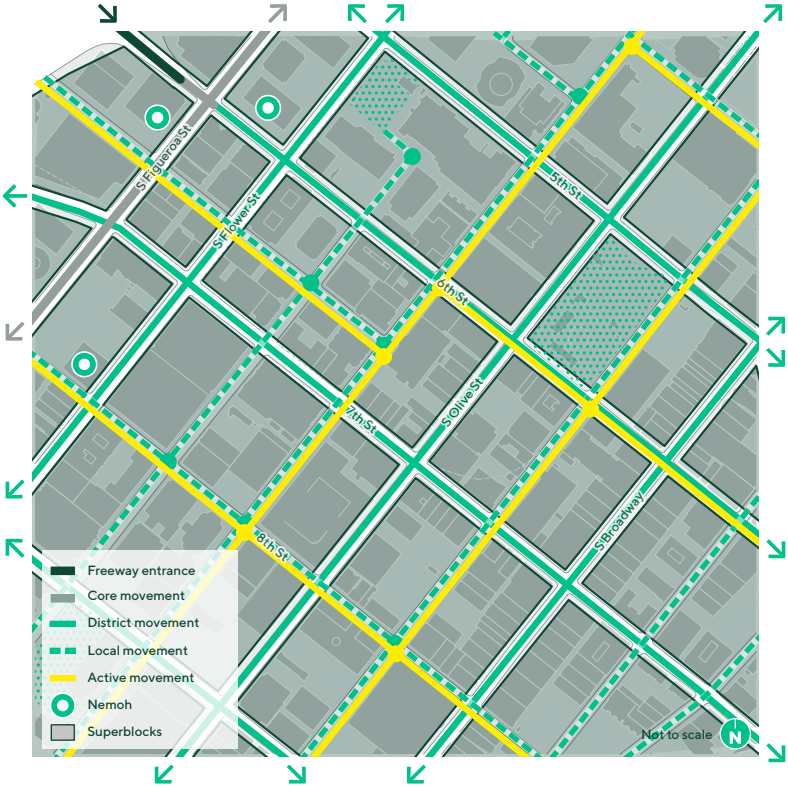
Local streets will work as linear water retention systems and as green/ecological corridors to permit dispersal for plants and animals. These corridors could play a key role in restoring and maintaining biodiversity and continuity of ecological processes in a heavily modified environment such as DTLA.

Environmental quality is also directly related to tree cover in cities. Trees and woodland can provide great benefits to the urban environment by providing shade and beauty, and playing a substantial role in the overall functioning of this system of parks and corridors through its ecological benefits, and cooling effect. The American Forest Association recommends

[29] Sukopp, H. (ed.) 1990: Urban ecology – the example of Berlin, Dietrich R

trees coverage in cities of up to 40-60% if attainable under ideal conditions in forested states, 20% in grassland cities, and 15% in desert cities like Los Angeles. These are realistic baseline targets with higher percentages possible through greater investment and prioritisation.[30]

The CAVs super grid will be a great occasion for a city lacking in woodland and green spaces to start implementing these policies, addressing habitat fragmentation in its core and by doing so, improving its ecosystem values.



Composite – new CAVs super grid system

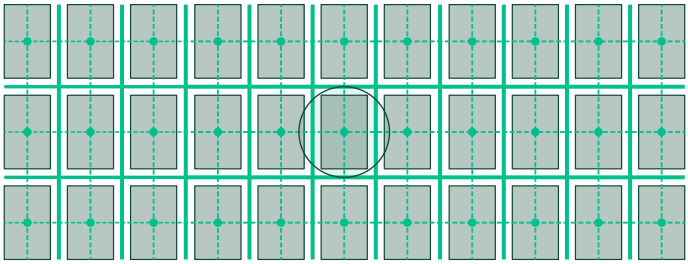
[30] See American Forest Association. Setting Urban Tree Canopy Goals. http://www.americanforests.org/blog/no-longer-recommend-40-percent-urban-tree-canopy-goal/

Movement and place

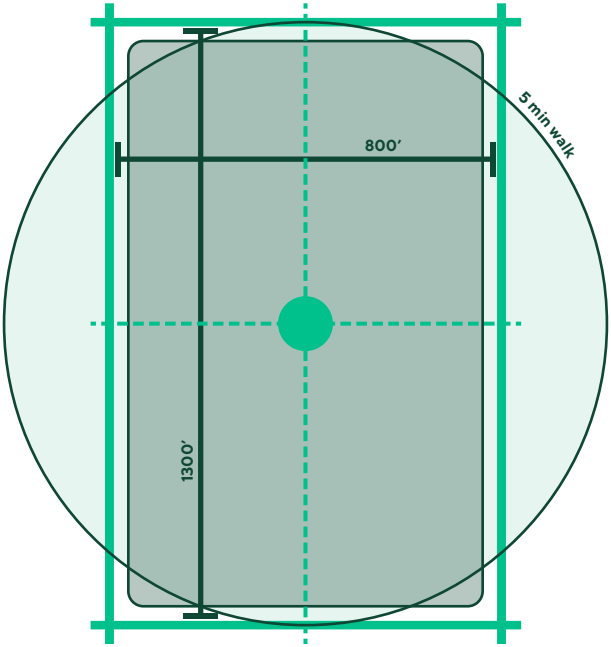
In this section, we present a few suggestions on how DTLA streets could be redesigned following the CAVs super grid vision. This, in our mind, is the beginning of a tool-kit of ideas and possible re-configurations of city's parts within an incremental strategy.

The diagram below shows a typical super block configuration, consisting of four city blocks for a total dimension of approximately 680 by 1,300 feet. It is served on the four sides by movement district streets and internally by two local streets. The longest dimension is about a 5-minute walk end to end.

Urban grid



Super block



District movement streets

District movement streets will accommodate primarily CAVs mass transport and shared CAVs systems services with the function of connecting the different districts within the core. Streets will be re-converted into a two-way system and private CAVs movement will not be permitted on this type of streets. Maximum speed limit for CAVs will be 15 to 25 mph.

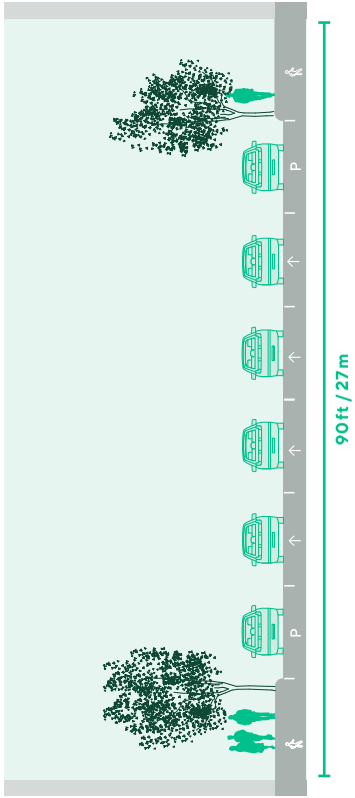
The diagram below shows a current typical street section within our study area, in this case Olive street. The building to building distance is about 85 to 90 feet. Of this length, about 10 to 12 feet per side are dedicated to pavements – 24 feet total, and the rest of the 65 feet to one-way vehicular traffic, with street parking on both sides.

By using the CAVs super grid model, we could imagine Olive street becoming a district movement street. The next diagrams show how the street section could be redesigned this way, essentially as a mini multiway boulevard.

The central portion of the street will accommodate shared CAVs through-traffic and mass transport services. Because of CAVs efficiency, only one lane per direction will be required. Central lanes will allow a maximum speed of up to 25 mph. Median strips on the two sides will provide space for pedestrians to comfortably cross the street at the two ends of the block and in the middle (at certain locations) and sensibly reduce crossing distances. Medians will also be used to allocate stop/waiting areas for mass transport services, for green/blue infrastructures, and for planting trees.

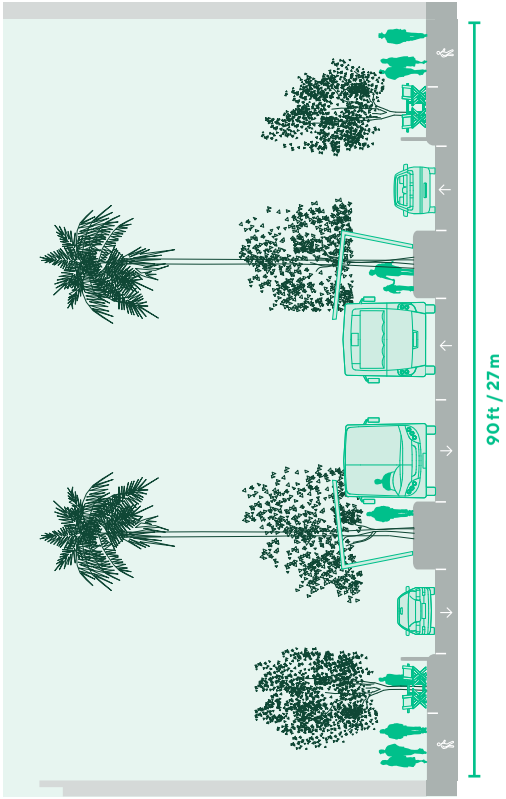
On the internal sides, one lane for CAV movement each way will provide local access and service to the single parcels, to drop-off and pick-up kerb sides areas or 'hodos', and to access the district's mobility hubs, where CAVs could temporarily park, get service, or recharge. The maximum speed on these lanes will be 15 mph and could be shared by cyclists. Pavements will be extended to a minimum of 15 feet where possible. This will provide space for pedestrians to walk as well as sit and socialise, to improve the landscape and trees offer, and to add to the urban realm amenities.

District movement street, existing conditions



District Movement street, future conditions

District Movement street, future conditions with CAVs transport stops



Local movement streets

Local movement streets will serve to guarantee users access to single parcels within the super block. They will have a maximum speed limit of 15 mph and shared CAVs services will use them only if the origin or destination of the trip is on that street.

The diagram below shows a current typical street section along South Grand Avenue. The building to building distance is about 85 to 90 feet. Of this length, about 10 to 15 feet per side are dedicated to pavements and the rest of the 65 feet to one-way vehicular traffic with street parking on both sides, similarly to Olive street. Recently, the City of Los Angles has implemented a Complete Street scheme on this section of the street.

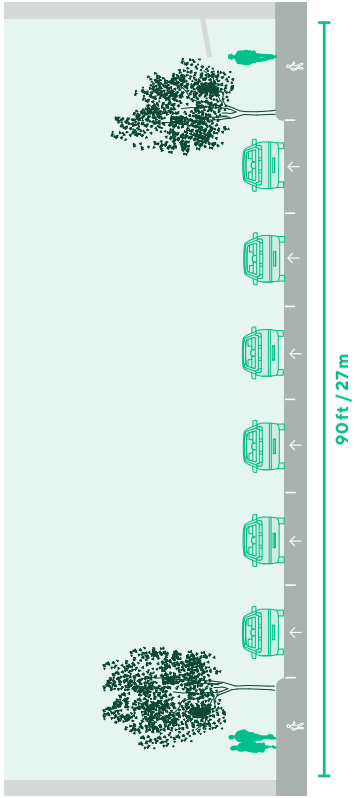
By using the CAVs super grid model, we could imagine this portion of Grand Avenue becoming a local movement street. It will have a maximum speed limit of 15 mph and shared CAVs services could access it only if the origin or destination of the trip is in that street. Users will use the street to access single parcels, to reach an hodo, or to use the new amenities of the enhanced public realm, or simply to stroll along.

The central portion of the street will accommodate shared CAVs local traffic. Because of CAVs efficiency, only one lane per direction will be required or about 25 feet or less to accomplish this. Medians on the two sides, by reducing crossing distances, will provide space for pedestrians to comfortably cross the street in multiple points along the block length. Medians will also demarcate user areas, provide space for drop-off and pick-up, or hodos, for placing green/blue infrastructures, and for planting trees.

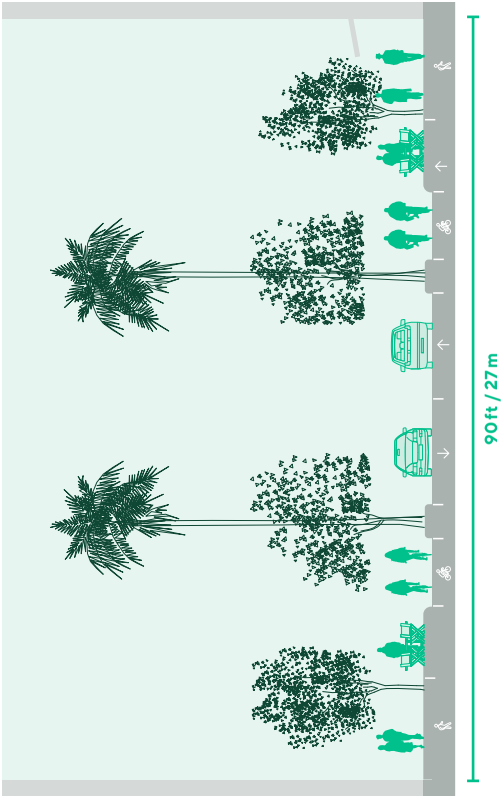
The internal sides of the streets will be used to accommodate the active grid layer and the ecological corridor functions. The diagram below shows two cycle tracks of two lanes each, fast and slow, on the two sides that could be used for primary (i.e., commuter) trips, and secondary (i.e., local) trips.

Pavements will be extended to a minimum of 15 to 20 feet. This will provide space for pedestrians to walk as well as sit and socialise in correlation to the ground floor uses, and to add to the landscape and trees offer. Pavements and medians will accommodate the linear storm-water retention system. The combined landscape and previous surface treatment will act as an ecological corridor to permit the dispersal of plants and animals, while contributing to the reduction of the heat island effect.

Local Movement street,
existing conditions



Local Movement street,
future conditions



Local intersections

Local street intersections in the middle of super blocks will be redesigned to become plazas, squares, or pocket parks and provide new public amenities and cafés. This will be the centre of social interaction for the super blocks.

The diagram below shows how the intersection at Grand Avenue and 8th Street functions today. Both streets are one way, with 3 lanes each and on-street parking on both sides. A recently class II bike lane was added on Grand Avenue. Of the current 10,000 square feet of the intersection area, about 85% is reserved to automobile use. Still, this is probably one of the best intersection in DTLA for pedestrian comfort and safety.

The next diagram shows how the intersection could be reimagined following the CAVs super grid approach. The intersection will have a maximum speed limit of 15 mph, with two converging local movement streets. Shared CAVs services will use it only if the origin or destination of the trip is within the super block. Less than 50% of today's surface will be needed for CAVs movement, leaving the remaining square foot for other uses and users.

The sketch illustrates how the intersection could be redesigned in combination with the transformation of an adjacent parking lot into one of the public parks already described. These new public spaces will be designed as pedestrian-first types of environments, and with a 'shared' quality approach. Other users will have to negotiate space among the different modes with minimum or no traffic separations.

Demarcation of users space will be achieved by differentiating street surface materials and patterns, through landscaping,

Existing Proposed

Local movement streets intersection

placing bollards strategically, or adding other street furniture elements. CAVs drop-off and pick-up spaces will be provided along local movement streets kerb sides. The geometry of the street is redesigned to accommodate new functions with added active programs within the street section. These new public, or publicly accessible open spaces will foster a mix of uses and users, promote sociability, and will be programmed to be active for most of the day and part of the night.

In the redesign of local intersections, it will be important to preserve minimum widths and areas for ecological functioning, so to increase their ecological value. These spaces will offer potential areas for the natural filtration of water into the ground, including runoff from hard surfaces from the intersection itself, and from adjacent residential and commercial areas. Impervious surfaces should be limited and replaced with alternatives to improve infiltration and percolation.

Pavement kerb

CAVs Super Grid streets in urban cores will be living streets, streets designed primarily with the interests of pedestrians in mind, social spaces where people can meet, and with a shared space approach that will greatly reduce the demarcations between vehicle traffic and pedestrians.

When vehicular movements will be all CAVs, pavement kerbs as we experience them today could mostly disappear. There will be no need to discourage drivers from parking or driving on pavements. Kerbs in some conditions could still be used to channel runoff water into storm drains and to keep pavements areas dryer, or used for aesthetic purposes.

Most streets, in the CAVs Super Grid model, will be redesigned at the same grade as pavements, without kerbs, or with minimum kerbs heights (1 to 2 inches). This will allow maximum pedestrian comfort and accessibility for people with limited mobility, while CAVs will be limited to a speed that does not disrupt the other uses of the streets. Demarcation of different users' space will be achieved by a rich physical environment of contrasts in terms of surface tactility, materials, patterns, colours, and the enhancement of sound and other sensory clues, by using bollards, and by landscape elements. Minimum kerb heights could be used to help navigate visually impaired people.

The need for drop-off and pick-up space will increase exponentially. In urban cores, this will mostly be provided

along streets near kerbsides, in a public and shared type of environment, and will serve multiple parcels and different types of users through the day (and night). These areas will have preset or real time waiting time limits regulated by the local authority. For passengers, this will typically be of up to 5 minutes during peak demand times and possibly charged.

CAVs' new mobility hubs (Nemoh)

As already discussed in other sections, CAVs parking & waiting stations in urban cores will be provided by a system of hubs organised with a core and districts parking strategy, regulated by local municipalities.

These hubs will not only accommodate CAVs and their needs – waiting, parking, recharging, and servicing – but will first and foremost serve the users through their urban journey, providing them with a menu of mobility options, services and shops, goods delivery and pick-up, and a comfortable place to wait, relax and socialise.

Mobility hubs, in a CAVs urban environment, will be of different types and sizes and will serve different but correlated purposes. In our super grid strategy, we have identified a four levels hierarchy of CAVs' hubs: core mobility hub, district mobility hub, super block mobility hub, and remote mobility hub.

Real-time congestion charges will regulate the amount of privately own CAVs reaching cores and where they will park. Privately owned CAVs will drop-off/pick-up owners in a dedicated core hub at the periphery of the core and then self-park in a remote hub in a less valuable location, depending on time of the day and waiting time, as directed by congestion charges incentives/disincentives. From these core hubs, passengers will shift for their last mile to a shared CAVs system, use transit, bike, or walk, to reach their final destination in the core.

Multiple district mobility hubs located along entry points will provide a more capillary system to serve individual districts within the core. Smaller super block hubs will provide fine grain accessibility and services at the super block level. In most cases, these types of hubs will be located along district movement streets. Real time congestion charges – depending on factor like route congestion, close-by parking availability, or waiting times, will regulate shared CAVs parking distribution within the different facilities of the district.

Parking and other implications for the built form

Parking policies and the way vehicles access properties will change dramatically in a CAVs super grid system. This will trigger a cascade effect on the design and layout of buildings. For DTLA we would aspect a scenario in which:

- Parking minimums will be replaced by maximums.
- Maximum parking standards will include the amount of kerb allowed for drop-off or extent of hodos.
- On site drop-off areas will be generally banned or restricted to specific uses.
- Hodos would be taxed by use to recover some of the municipal revenue losses from parking revenue and tickets.
- As on-site parking and parking lots disappear or shrink, buildings will increasingly have less 'back of the house' and more and more frontage. This is particularly relevant in Los Angeles where most of the buildings access today happens from the rear, or from wherever parking is located.
- The relationship between public space and the private sections of the buildings will improve and the importance of lobbies and transition areas will increase as these will be the prime connectors to and from the buildings to a shared CAVs.
- A process of cross-contamination of functions and spaces will promote the creation of a diffuse semi-public space at the ground floor and on the public pavements.

Interim phase

We imagine our proposed CAVs super grid not as a futuristic vision, but as a strategy that the Los Angeles region could start implementing in its cores incrementally starting today. The next 20 years will be an interim phase in which CAVs and manually driven automobiles will coexist in the majority of Los Angeles' streets.

The opportunities created by shared CAVs should be looked at closely, as they could be a strategic tool to solve the current mobility issues of Los Angeles cores. Provided that the deployment of CAVs could deliver the expected benefits, they will be able to make a difference only if deployed on a large scale. In this sense, accelerating adoption will be critical.

Local authorities in DTLA will be required to take drastic decisions and redistribute space between different users by:

- Allocating dedicated corridors to shared CAVs where manually operated cars are banned to ensure that there will be minimum mixing of the two types of vehicles.
- Creating a much better cycle infrastructure, and faster than it is being currently done. In the short-term cyclists could be the most disrupting element for CAVs, therefore a world class cycle infrastructure will limit conflict with CAVs as well as responding to rising demands.

C-Corridors could complement the traditional hierarchy of the road network but may not necessarily with it. In the beginning, this could be a separate layer that will be part of the road network used by manually operated cars and public transportation only at key points.

The next diagram suggests how during the interim phase – as phase one – corridors with shared CAVs and transport only lanes could be progressively introduced in DTLA.

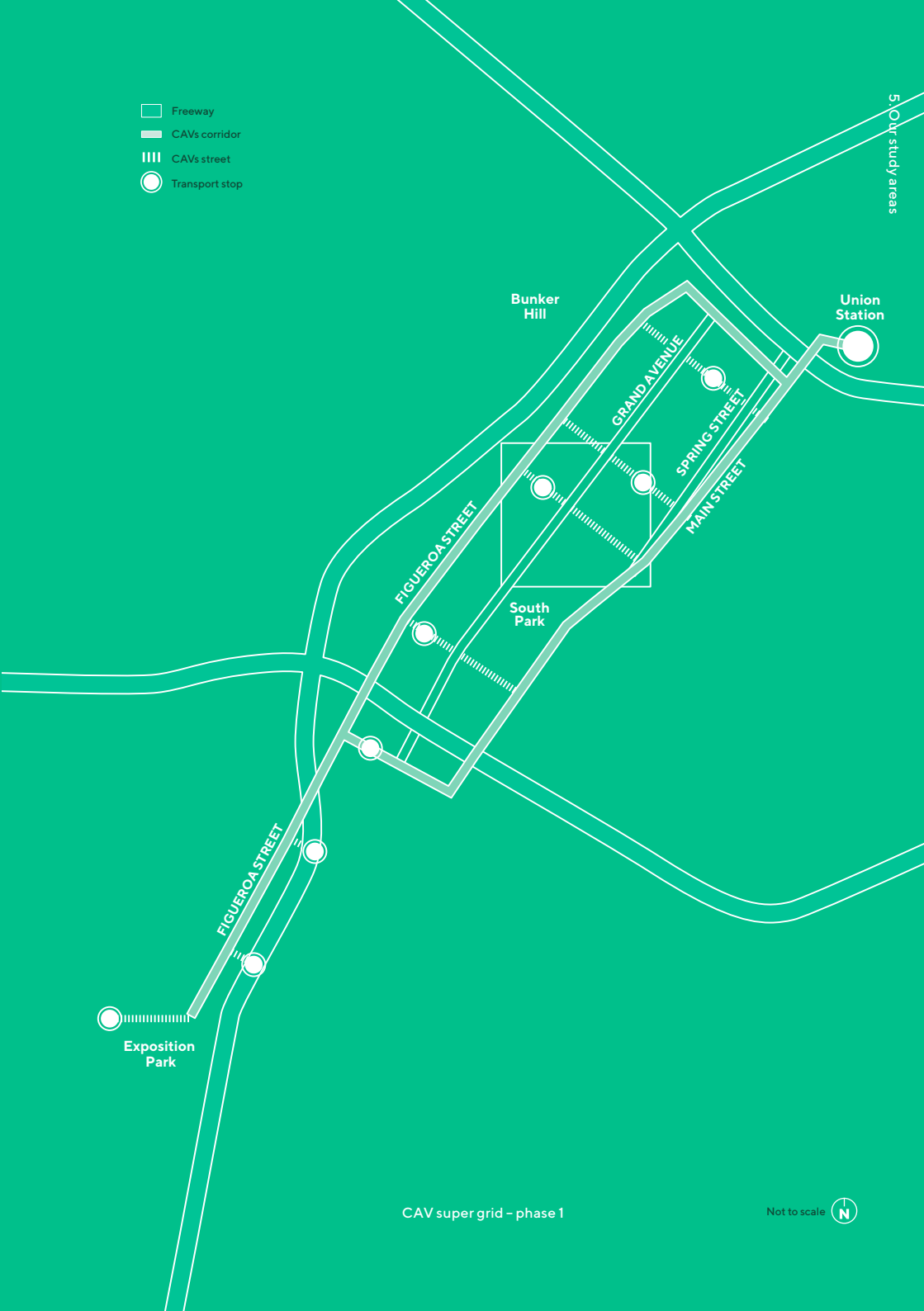
Our idea is to start by creating a loop of dedicated shared CAVs and transport corridors through downtown from Union Station north to Exposition Park south. This will connect most of the rail stops, landmarks and parking areas from the Civic Centre district to the University of Southern California (USC) campus, and serve the majority of the commercial and residential areas for local trips and as first/last mile alternatives.

In this scheme, Figueroa and Main street could accommodate the main north-south CAVs movement corridors, and the first to be reconfigured as multiway boulevards with dedicated shared CAVs and transport lanes, along with the two east-west connections.

Secondly, within the loop a further CAVs hierarchy could start to be introduced for local streets. Grand Avenue, Spring Street, or Broadway Street, because of their unique civic, mixed-use, or historical character and identity, would be among the first where street reconfigurations and CAVs only services are tested.

As CAVs technology improves and become more diffused and accepted, the CAVs super grid can progressively be delineated within the loop area and mobility hubs be identified around the perimeter for easy mode exchange. Manually driven cars at this stage would be progressively discouraged to access the area within the loop.

Once phase 1 is consolidated for the central part of the core, the same approach of C-Corridors could be expanded east



CAV super grid – phase 1

Not to scale N

of Main Street to reach the Fashion District and the Arts District, and ultimately the LA River; and north to incorporate Chinatown.

A dedicated shared CAVs and transport corridor, for instance on Main Street, could have a similar section to a district movement street, with the exception that traffic direction could be one way or two ways and manually operated cars could use part of the section. Central lanes will be reserved initially only for private and shared CAVs as well as for public transit, with private CAVs excluded in a second phase. Side lanes could still be accessible to manually operated automobile traffic as well as to CAVs for pick-up and drop-off. Speed limits will be similar to a district movement street.

The intent in phase 1 is to build momentum by giving CAVs type of services, micro transit, and importantly, to regular transit, priority over private automobiles, by progressively increasing accessibility to the system and gaining acceptance from the public.

This will also be the time to find the political will to reclaim spaces from car uses to higher and better uses, and CAVs will provide that opportunity. Many of the ideas and concepts presented in the CAVs super gird are already applicable during the interim phase, as the different levels of CAVs automation will be able to navigate streets environments as we experience them today and coexist with cars.[31]

Furthermore, these concepts could be applicable even if the CAVs evolution does not happen at all, and instead an efficient public/private multimodal system is developed around this framework. The aim in our minds, after all, is to drastically reduce the need for single occupancy vehicles to access and move through Los Angeles' urban cores.

[31] https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety
https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

6

CONCLUSIONS AND NEXT STEPS

"Automobiles are often conveniently tagged as the villains responsible for the ills of cities and the disappointments and futilities of city planning. But the destructive effect of automobiles are much less a cause than a symptom of our incompetence at city building."

– Jane Jacobs, The Death and Life of Great American Cities

6. CONCLUSIONS AND NEXT STEPS

This work starts to explore the many implications, changes, and possible new configurations (or re-configurations) that the CAVs evolution may bring to our urban environments, and ultimately, to everyone's everyday life very soon. It is a work in progress, and will evolve, as will technology and consensus of the larger planning community.

Despite these limits, the strategy presented for the two areas in London and Los Angeles starts to showcase the potential to plan for CAVs in such a way as to facilitate the reconfiguring of mobility and public realm in urban cores. Furthermore, it suggests how CAVs could trigger an even larger process of urban regeneration and economic development, ultimately reshaping real estate and architectures, responding to and promoting new lifestyles. Most importantly, it suggests how we could use CAVs as tools to improve the performance of our cities and to address some of the most intractable issues they are facing.

We purposely showcased a softer approach for the deployment of CAV services in London. With the right political will, this could be implemented incrementally in the near future, and could be applicable with some adaptation and refinement in many other European city cores with pre-industrial urban configurations facing similar circumstances, such as: constrained right of ways, densities, mix of uses, layers of history, heritage, culture and governance. The approach would help introduce CAVs in a more manageable way into our urban areas and into our lives, while also helping unlock potential for walking, cycling and environmental improvements. It also help promote the benefits that CAVs can offer through reduction of private car usage in urban areas.

In Los Angeles, by contrast, we presented a broader approach focused around the urban grid plan, probably the most distinct and democratic character of an American city, and typical of colonial and post-industrial development patterns. In this case, we started from a long-term framework, the CAVs super grid, to then propose how a first phase of a much broader vision could be implemented relatively soon.

This CAVs strategy could be applicable in the cores of other American cities as well. American cores benefit from having

space available for transformation and possible reuse, thanks to the original dimension of the grid plans and to more generous standards for development when compared to European cities. However, American cities must also overcome decades of persistent car-centric urbanism; right of ways are enormous compared to European examples and, typically, cores have less of a mix of uses and layers of historical stratification.

The comparison between London versus Los Angeles starts to imply how transformative a CAV-based strategy could be in very different settings and markets, and with different societal values and lifestyles. In both cases, it is evident that a contextual approach is needed. Also, even if the two approaches are at the two ends of the implementation spectrum, they would still have to overcome the same hurdles in terms of public acceptance. This is why both approaches (and any other proposed) should be tested as soon as possible in the same fashion by using driverless car trials on our streets: as CAVs learn by driving, cities can learn to use driverless cars and exploit them to solve their issues.

It seems to us that the major challenge for city makers will be to guide the transformation of urban environments by fostering the acceptance and public use of this new technology, while progressively discouraging single occupancy automobile use. It is important to get this transition right. The cost would be creating another difficult legacy, a rigid infrastructure that will work against the principles we are promoting. The risk is real and quick adoption will be important to reap the benefits of CAVs.

Big choices and large investments will be required, for example, in banning manually operated cars and successively private CAVs; in creating dedicated C-Corridors; or in creating a new infrastructure of CAVs and mobility hubs. There are also apparently small choices that could create challenges, for example in terms of dimensions: allowing CAVs to be more than two meters wide would result in losing some of the gains from their efficiencies in space allocation; allowing excessive platooning will affect street vitality; not managing and sharing space between serving, deliveries, and CAVs drop-off would radically reduce the amount of space available for environmental improvements, as much as not limiting the sections of drop-off areas along the pavements; and so on.

Whether the choices are big or small, we need the public sector to catch up with the incredible challenges and opportunities

created by CAVs. It is worrying to notice that in the UK little to no consideration is given to CAVs in policy documents that are meant to guide the way we will plan and develop our urban areas in the next two decades.[1] In the US there are some early attempts by regional and local authorities, but typically only with generic demands to take into account future technological advancements rather than setting the agenda for how CAVs should deliver certain benefits.[2] Meanwhile, urbanists have been, for the most part, disengaged on the topic with the risk of leaving the planning field open to technologists, manufacturers, or other specialists who do not necessarily set the best trajectory for social well-being or urban sustainability.

In the UK the population will reach 73 million by the beginning of the 2040s.[3] At the same time, urban development globally remains founded on a heavy dependence on the automobile. With this forecast, in conjunction with climate change challenges, formulating a pragmatic vision on CAVs and urban design seems more relevant than ever. CAVs could be a sustainable answer to urban transportation, open up to a post-car world paradigm, and create opportunities for resilience and climate adaption thanks to the changes that they could bring to the physical fabric of cities.

In order to do so, CAVs will have to be:

- **Electric** so to cut down pollution in urban environments (though we still need to address the issue of the energy source to produce electricity); connected – so to optimise and make more efficient use of the road network and free space;[4]
- **Shared** expanding the number of passengers per vehicle[5] and expanding the pool of users to elderly, teenagers, disabled, while contributing to freeing more space for other uses; and

[1] Even the Mayor's Transport Strategy, Draft for public consultation (June 2017) relegate CAVs to a cautious open ended paragraphs at page 261.

[2] See ENOTRANS for the current state of policies related to automated driving in USA: https://www.enotrans.org/etl-material/adopting-adapting-states-automated-vehicles/

[3] www.ons.gov.uk

[4] http://www.reinventingparking.org/2013/02/cars-are-parked-95-of-time-lets-check.html

[5] Regarding US latest commuting trend see: https://www.usnews.com/opinion/economic-intelligence/articles/2017-09-18/what-new-census-data-reveal-about-american-commuting-patterns

- **Flexible** through public and private partnerships CAVs services could help make fixed mass transport service more functional and accessible, particularly by filling first-last mile gaps.

We look forward to work toward this future. Meanwhile, in continuing our work, we will test these ideas on other city fabric types and against different contexts in cities with different characteristics. Our ultimate goal is to provide a positive vision for CAVs and the city. We hope that our work will contribute to the formulation of a pragmatic vision on which different actors and the public could converge.

7

WHO WE ARE

7.
WHO WE ARE

We are Steer Davies Gleave, we are an independent employee-owned consulting firm. The core areas that define us are place, environment, movement and identity. We combine our understanding of human experience, perception and behaviour to deliver innovative, user-centred design which helps to make our cities, neighbourhoods and public places understandable, accessible and enjoyable for all. Our design team's combined expertise covers urban design, masterplanning, streetscape design, engineering, wayfinding, place-branding visual identity design, and cartography.

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If you want to get in touch with us to discuss the design implications of CAVs, please reach out. We will be happy to engage with you and to take forward the discussion on CAVs and cities!

8

GLOSSARY

8.
A SHORT CAVS GLOSSARY

Artificial intelligence (AI) Computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and driving in the case of CAVs.

Autonomous vehicle A vehicle that is capable of fulfilling the operational functions of a traditional car without a human operator, typically classified at level 3 automation or above. See also Automation.

Automation (levels) Use of machines that operate automatically. When applied to cars (autonomous vehicles), the level of automation varies according to the degree of automated technology embedded in the car. There are 6 levels of driving automation as defined by SAE International. These are:

- **Level 0** No automation. A human controls all driving tasks, even when aided by warning systems.
- **Level 1** Driver assistance. A human controls most driving; the vehicle performs either specific steering or acceleration/braking tasks.
- **Level 2** Partial automation. The vehicle performs both specific steering and acceleration/braking tasks; a human being controls all other driving.
- **Level 3** Conditional automation. The vehicle performs driving in some modes; a human intervenes when requested.
- **Level 4** High automation. The vehicle controls specific driving modes without human intervention.
- **Level 5** Full automation. The vehicle controls all driving, full time, without human intervention. See also autonomous vehicle.

Connected Autonomous Vehicle (CAV) A vehicle that integrates both autonomous and connected technologies. See definitions of autonomous vehicle and connected vehicle.

C-Corridors (CAV corridors) Continuous sequence of streets designed to priorities pedestrian, cycle and CAVs movement. It normally bans access for traditional cars.

Connected Vehicle A car equipped with technology enabling it to connect to devices within the car, as well as external networks such as the internet.

Electric Vehicle (EV) A car that run at least partially on electricity. Unlike conventional vehicles that use a gasoline or diesel-powered engine, electric cars and trucks use an electric motor powered by electricity from batteries or a fuel cell.

E-hailing The process of ordering a car, taxi, limousine, or any other form of transportation pick up via a computer or mobile device.

Geo-fencing Feature in a software program that uses the global positioning system (GPS) or radio frequency identification (RFID) to define geographical boundaries. It has multiple applications for CAVs, including the definition of the areas permanently or temporarily accessible by the vehicles.

Hodo (Hop-on-drop-off) Facility designed for the collection or delivery of goods and people with vehicles. They are normally on street and occupy dedicated bays.

Induced demand Increase use of transport infrastructure following its increased provision. For an account on the history of induced demand see: http://www.roadswerenotbuiltforcars.com/induceddemand/

Inductive charging (or wireless charging) Use of electromagnetic field to transfer energy between charging stations and vehicles without the need of connecting cables. It applies to parked vehicles as well as in movement.

Macroblock (or Superblock) Reorganisation of mobility in a section of the city obtained by changing the road network and creating separate routes for different modes of transport: in general motorised traffic is allowed at the edges, while the inner streets are dedicated to pedestrians and cyclists. Early tests of this approach have been carried out in Barcelona.

Mobility as a service Future service driven by a mobility provider. The passengers over the cloud can give their requirements for being transported, and the mobility provider will arrange this and send the autonomous agents to the passengers that the agent can transport.

New mobility hubs (Nemohs) Transport interchanges featuring CAVs. There are different types of Nemohs categorised as Major, Neighbourhood and Remote depending on their location, level of integration with traditional transport modes and function (storage, servicing and access).

Platooning Use of connectivity technology to enable CAVs to form and maintain a close-headway formation.

Sustainable Urban Drainage Systems (SUDS) SUDS mimic nature and typically manage rainfall close to where it falls. SUDS can be designed to transport (convey) surface water, slow runoff down (attenuate) before it enters watercourses, they provide areas to store water in natural contours and can be used to allow water to soak (infiltrate) into the ground or evaporated from surface water and lost or transpired from vegetation (known as evapotranspiration). From http://www.susdrain.org/

Ride-sharing E-hailing car service in which the driver is able to make multiple stops and pick up different passengers going in the same direction.

Shared space Urban design philosophy eliminating physical segregation (horizontal and vertical signage, kerbs, furniture, etc.) between road users. The resulting uncertainty acts as a natural traffic calming measure.

Transportation-as-a-Service (or Mobility-as-a-Service) Transport delivered and consumed as a service as opposed to be available in the form of a private car.

Vehicle-to-Vehicle Communication (V2V) Vehicle-to-vehicle communication's ability to wirelessly exchange information about the speed and position of surrounding vehicles.

9

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This work is a collective effort of an interdisciplinary team of professionals at Steer Davies Gleave. It has involved experts in urban design, architecture, intelligent mobility, transport planning, landscape architecture, and highway engineering. The project was completed in March 2018 and coordinated by senior staff of our Urban Design team.

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