Shaping Urban Accessibility: Technology’s Place in a Sustainable Future
Introduction

The Royal Borough of Greenwich, like many other urban centres, is undergoing significant change. The population is predicted to grow by 34% between 2010 and 2028, with an increasing skew towards the 65 plus age bracket.

This growth is not just restricted to Greenwich. The UN predicts 70% of the world’s population will be urbanised by 2050 (UN, 2017) compared to only 30% in 1950. This level and pace of growth presents cities with multiple and complex challenges. Cities drive economic and social development as hubs of commerce, innovation and government, and their continued success is of crucial importance in enabling long-term prosperity and natural resource efficiency.

The core of this paper explores how spatial planning, technology and automated vehicles (both how they look and feel and the services they enable), and especially the interrelation of these areas, are all crucial to ensuring we can grow our cities sustainably, providing urban accessibility and mobility for all residents.

The GATEway project, based in Greenwich and which DG Cities is helping to deliver, is exploring and implementing some of the ideas raised in this paper. The project is focussed on understanding people’s behaviour, attitudes and expectations around driverless mobility and what future vehicles and services could look like, informing new research into the opportunities for cities and how they need to respond to maximise them.
The evolution of cities

The evolution of cities’ urban morphology and design, urban travel patterns, and residents’ preferred mode of transport have evolved over time. In the pre-industrial city most travel was on foot. Hence, people lived close to where they worked and this resulted in compact and dense human-scale urban settlements.

Subsequent technological advances, during the industrial revolution, allowed for large scale urbanisation. This urban expansion was initially driven by buses, a developing underground system, and metropolitan and regional rail systems, which permitted faster travel. People could gain access to a wider geographical area, allowing cities to expand beyond their existing limits.

During the 20th century further technological progress pushed down mobility costs relative to incomes. Widespread adoption of privately owned cars became commonplace and cities de-densified and expanded horizontally as people prioritised larger homes away from urban centres; the suburban lifestyle and ‘commute’ were seen as a desirable lifestyle choice.
Throughout this journey – from the pre-industrial city to today, access by proximity has been substituted with access by movement and cities have evolved from dense and compact urban settlements to sprawling ones. In these cities the majority of employment is located in a single urban core and housing is connected by roads or public transport links.

This business-as-usual trend is leading to sprawling and car-dependent cities whose space requirements imply further de-densification, greater congestion and higher parking pressures on public space (Kersys 2011; World Bank 2014). These in turn lead to issues related to:

I. Decreases in productivity due to congestion and time lost commuting
II. Greater social exclusion that occurs through segregation by transport modes
III. Deteriorated health through pollution and lack of movement
IV. Increased pressure on the environment through larger urban footfall and resource demands

The secret of safer, more prosperous, innovative, sustainable and resilient urban societies lies in the successful integration of the different systems that create the urban environment and make it “liveable”. To resolve this, we need to think more holistically and embrace a paradigm shift away from the concept of urban mobility in favour of urban accessibility, and the important opportunities connected and autonomous vehicles create to support this shift.
Moving towards an integrated approach

The framework proposed in this paper embraces this paradigm shift. The objective is to think more in terms of ‘urban accessibility’ rather than exclusively in terms of ‘urban mobility’. Accessibility can be achieved/increased through:

I. the optimal distribution of uses and functions across the space, that is, by working on the city’s urban morphology;

II. the development of transport networks, systems, and mobility services;

III. the smart and good design of the vehicles providing these mobility services, and

IV. the deployment and adoption of digital infrastructure and new technologies.

Therefore, we propose the following four pillars of an integrated framework approach:

I. Design of the built environment;

II. Digital infrastructure and new technologies

III. Design of new mobility services;

IV. Design of future vehicles

Understanding each of these pillars, both in isolation and as a whole, is critical to developing solutions to sustainably servicing city growth.
Design of the Built Environment

‘Urban morphology’ refers to the form and structure of urban settlements. The form is defined by density patterns, building typologies and the pattern with which these are repeated across the territory – urban grain.

The structure of urban settlements refers to the articulation of urban centres (monocentric or polycentric) and the distribution of uses and functions across the space. The city’s urban morphology/physical infrastructure is a ‘hard and static’ urban system and hence it has a significant impact on the degree of flexibility of the other urban systems, as it is the ‘spatial scenario’ in which other systems, such as energy, mobility/accessibility, economy, social inclusion, health, etc will be deployed.

The following two different city models: ‘the sprawl and segregated use’ city and ‘the compact and mixed use’ city correspond to different urban morphologies.

In the ‘sprawl city’ uses tend to be segregated spatially – there is an area in the city where people live, another one where they work, a different one where they socialise, another one where they do their shopping, etc. Hence, these cities are highly reliant on city trips due to the large distance between uses, facilities and activities that constitute the daily routine. This results in an extensive and inefficient transport network. The sprawl city model favours individualised motorised transport, which constantly requires more and more space and leads to further sprawl. A good example of this would be Los Angeles.

On the contrary, in a ‘compact and mixed use’ city, these different uses overlap spatially. The city is designed to meet the daily needs of its citizens locally, by creating neighbourhoods where people can live, work, socialise, do their shopping, etc. All these different uses and functions lie in close proximity, at walking and cycling distances. This minimises the need to travel in the city and as a result, the transport network is public transport oriented, much more compact and efficient. Again, an example from the USA would be the San Francisco Bay Area or the Medway in Kent.

Figure 2 - Two different city models of different urban morphologies.
Source: DG Cities - Lola Fernandez-Redondo adapted from Rogers Stick Harbour & Partners
Digital Infrastructure and New Technologies

Following on from a city's spatial design, the technology infrastructure that is layered on top must also be given due consideration. Technology and digitalisation are the main drivers of change in the current development context. It has a highly disruptive impact on our economies, societies, environments and behaviours.

Fixed and mobile ultra-fast broadband has become a source of competitive advantage in the struggle to create more dynamic business and social environments. Through emerging technologies like BIM (Building Information Modelling), IoT (Internet of Things), Satellite technologies, data analytics, systems integration and artificial intelligence, the world is shifting from a problem-solving approach to a predictive and resilience-based approach.

Through Big Data and advanced analytics capabilities, we are able to identify trends, anticipate challenges and react and address them before they become problems. This has a beneficial impact on our resource consumption patterns as predicting and addressing potential future challenges is considerably less resource intensive than reacting to emerged problems. New digital technologies allow a much more sustainable, resilient and productive world while they also contribute to delivering higher quality environments and living experiences.

Technology is not a panacea for existing challenges and issues however. The integrated approach we advocate in this paper requires significant focus on optimising the design of the spatial layer so that we can focus our technology efforts on underpinning new and innovative services rather than on retroactive solutions to poor spatial design. Realising the benefits of technology mean we must consider both the built environment, and the data that it produces, as an interconnected set of systems.

Design of New Mobility Services

The emergence of digital technologies is revolutionising mobility offers and options for getting around in the city. Among the emerging trends enabled by digitalisation is ‘Mobility as a Service’ (MaaS).

MaaS offers residents and transport operators alike a whole new way to travel and deliver services. Within MaaS, we move away from component trips and modes to the concept of ‘journeys’ from a customer perspective. It is envisioned that customers will be able to simply buy a journey from A to B through a simple mobile interface and then the operator takes care of the rest. For example, instead of a customer having to book a taxi, then a train and then take a bus, they will simply buy a digital ticket for their entire journey and the operator will optimise their journey across multiple modes as required at the time.

This user centric approach offers significant potential benefits from a social, economic and environmental perspective.

Digital technologies not only let passengers/commuters know about the mobility options available to them, and make payments seamlessly, but also, they facilitate new ways of delivering mobility services by moving away from fixed routes to flexible routes. MaaS has access to real time information re traffic flows, congestion and incidents; weather conditions; location of existing demand, etc. and based on this, vehicles define their routes
in real time to efficiently match/meet supply and demand. This enables the optimisation of the following resources at a combined system and user level:

I. **time** – reduced total vehicle and people hours on the network through optimising travel supply to meet demand dynamically, as well as route optimisation and reduced overall congestion;

II. **energy** – following on from the above, the energy requirements to fulfil these journeys will also be commensurately reduced;

III. **space** – vehicles will be delivering services more efficiently based on the above optimisation and hence, the road infrastructure space needed for will reduce. Unlike with the current fixed routes, vehicles will only occupy/circulate through the areas/roads where there is demand for mobility services at each specific time of the day, day of the week, etc.). The more efficiently supply matches demand the less overall space vehicles will require, leading to the ability to re-imagine and re-purpose current road space

### Design of New Vehicles

Over time we have seen the emergence of different types of vehicles and the evolution of their designs linked to technological progress.

In the current digital age, the greatest innovation/revolution in vehicle design derives from the embedding of intelligence and robotic technologies in vehicles, delivering what are known as Connected and Autonomous Vehicles (CAVs) – which can drive themselves with little or no human input. Based on the underlying digital connectivity networks, CAVs are able to communicate with other vehicles and people in their environment, recharge themselves automatically and manage their maintenance regime. They will also be able to collect and analyse real time information from their surroundings, providing a chance for high levels of optimisation.
Our proposed approach and solution

An Accessible City

As cities grow, they benefit from agglomeration. In order to maintain this positive trend, it is important that cities plan towards urban compactness and intensive mixed use. This can be enabled by ensuring that functions, uses and facilities in the city lie in close proximity, favouring walking and cycling distances and investing in public transport infrastructure. Cities that grow beyond their ‘optimal’ size tend towards productivity losses and diseconomies of scale – e.g. congestion, pollutions, social segregation, etc.

![Figure 3 - Urban Agglomeration and Productivity Gains Relationship. Source: DG Cities - Lola Fernandez-Redondo](image)

This poses questions around what the most adequate ‘city structures’ are. At first, the city centre accommodates higher densities and a greater concentration of jobs, amenities and services. Therefore, it is logical to favour radial movements towards the city centre and develop public transport accordingly.
However, as cities grow this structure leads to increasingly larger travel distances, longer and more energy intensive commutes etc. as discussed above.

Big monocentric cities are chaotic, unsustainable and lead to sprawl. Following the original problem of the separation of functions, cities that pass a certain size threshold require the decentralisation of functions, jobs, and amenities. These need to move closer to where populations reside, following a structured approach, that of the polycentric city model, which replicates the mono-centric structure across these new spaces.

The polycentric city has different city centres with different degrees of self-sufficiency and complementarity between them depending on their densities, intensity of uses, and densities of flows, which are in turn, linked to each centre’s accessibility levels.

The polycentric city is based on pyramids of intensification around main transport hubs. The areas around transport hubs (the black dots in the diagram above) accommodate higher densities and intensity of uses (the blue in the diagram is darker) and as we move away from the transport hub, the densities and intensity of uses diminish (the blue gets lighter). Moreover, this structured approach to the city’s design and morphology, enables the design and development of much more functionally structured and efficient transport networks.

A high quality designed built environment/urban morphology can tackle existing problems and prevent potential future challenges. It has the ability to condition the efficient use of resources in other dimensions including energy, mobility/transport, health and wellbeing, etc.
The high impact the urban morphology has on the performance of other urban systems, makes it the first pillar of the framework when looking to increase accessibility in urban environments. The other pillars can add benefits to the efficiency of a good urban morphology but never fully address the shortcomings of a deficient built environment, only ameliorate them slightly even in the best-case scenario.

Connecting It All Up

Digital connectivity underpins the solutions provided by the other three pillars. The ability of devices to communicate in real time is already transforming industrial operations and supply chains, the delivery of services and life in the home. More sophisticated applications of digital and communication technologies within the urban environment will enable:

I. Management and optimisation of resources by better matching supply and demand through platform technologies – e.g. energy; mobility, urban space/road infrastructure (based on real time monitoring of traffic and other activities taking place in the city), etc.;

II. Development of services with new capabilities in mobility/transport, health and adult care, education, etc.;

III. Automation of management facilities in streets (e.g. smart streets, smart lighting)

IV. Real time data collection and advanced analytics to increase understanding of complex urban processes

These smart and revolutionary digital capabilities are extraordinary tools to optimise the use of resources and tackle urban accessibility and mobility challenges, especially when deployed over the optimal urban morphology. In the absence of the latter, their ability to improve accessibility will be considerably undermined.

The vision for an accessible city can be created by using the solutions developed based on the concepts of the four pillars. The above described “Accessible City” concept can be interpreted to any real-world situation.
Mobility Services Fit for People

Different urban areas – based on their intensity of flows, uses, and urban morphology – have different mobility demands/requirements which not only need to be addressed by different types of vehicles but also by different types of mobility services – e.g. fixed routes like the ones offered by rail and underground services but also, more flexible and on-demand routes, facilitated by different types of road vehicles thanks to digital infrastructure and new technologies.

These different mobility services enable a polycentric city to establish appropriate and efficient connections between the different urban areas.

The concept of Mobility as a Service (MaaS) also enables a shift from asset ownership to usership. Studies indicate that the number of shared vehicles needed by a community to meet their mobility needs are considerably lower than the number of vehicles needed if each member of the community owned a private vehicle.

For fewer vehicles to meet the same mobility demand they need to be moving uninterruptedly. This not only increases the productivity of the asset – vehicles are constantly circulating delivering a service and not idle as private cars are most of their time – but it also leads to a better and more productive use of urban space in cities: if vehicles are constantly moving, all the space dedicated to parking in city centres can be allocated to other functions and more productive/beneficial uses.
In Greater London, the number of registered private vehicles in 2017 was 2,634,587 (London Data Store). According to the UK norm for parking spaces, the area required per car space is 11.52 m² (the minimum dimensions for a car space are 4.8 x 2.4 meters). Thus, the parking space needed for all the private vehicles in London adds up to 30,350 ha (the equivalent to 22 Hyde Parks) which, with the approaches and solutions explained above, could be dedicated to other more productive or beneficial uses.

Digital infrastructure and new technologies, through CAVs and real-time traffic management systems offer us the possibility to rethink the way we use the space, the way we charge for parking, and ultimately, the way we design the city and its street sections in order to deliver safer, healthier, more lively, productive, and inclusive streets, neighbourhoods and cities.

**Vehicles fit for each journey**

Digital technologies and smart systems can be applied to vehicles of different sizes and nature – cars, vans, buses, trains, shuttles, bikes, scooters, segways, balance boards, etc. The selection of the (right/optimal) vehicle in each area of the city needs to be linked to the area’s mobility requirements and demands.

![Figure 7 - Operational Space for CAVS: Complementing Existing Transport Offer to Increase Accessibility in Local Areas](source:Lola Fernandez-Redondo)

The design of different vehicles can help to optimise services, as well as to provide transport options for demographics of special needs such as people with disabilities, young or old. Key considerations are the appropriate size of the vehicle and whether they are more ‘bus-like’ or more ‘car/taxi like’; are they designed for short journeys where ease and speed of ingress/egress is important or for comfort over longer distances? Integration with mass transit systems, is in our view, of prime importance, which points more to the former and a greater emphasis on flexibility and convenience in the service offer.
Next Steps

DG Cities is undertaking further work to quantify the benefits predicted in the paper. Future work will be focused on building a ‘digital twin’ through parametric modelling software. This model will be used to analyse the interdependencies between factors affecting the urban environment and to provide urban planners and decision makers with relevant insights.

The intention is to enable the rapid and easily communicable visualisation of potential scenarios, supporting a broad range of urban planning and transport management applications in the future. Its parametric set-up would enable users to adjust a variety of levers (land use, demand, transport modes etc.) and model urban areas considering different urban environments. When developing the framework for the software, efforts will be focused on identifying how best to include lessons learnt from the White paper as well as the wider Gateway project and to map the modelling opportunities.

Work is currently being undertaken with Imperial College London to develop a feasibility study and relevant software architecture for such a software. This research also looks at finding gaps in current academic research and commercial modelling products to best position the capabilities of the software. This research, which will complete in March 2018, will culminate in a separate report detailing the findings.

In the future, it is hoped the software can inform future regulatory frameworks, as well as planning and urban design policies, which will help add further impetus for the deployment of connected and autonomous vehicles by highlighting their full economic, societal and environmental potential for cities. The objective is to ensure that urban development is future proofed and will benefit its citizens by contributing to a more sustainable, productive, resilient and smarter community.
DG Cities Ltd (DGC) is an Urban Innovation Company that specialises in the development and implementation of smart city approaches. It utilises advances in technology and data analytics to reduce pressures on city infrastructure, services, and the environment.

A subsidiary of the Royal Borough of Greenwich, it has played a prominent role in establishing Greenwich as one of the UK’s leading smart cities. In this project, DGC is undertaking research and development by supporting the trial and analysing the vehicle’s performance, efficiency and environmental impact.

GATEway was a three-year Innovate-UK funded project studying how autonomous vehicles will fit into the UK’s future transport mix, and the societal, technical and legal barriers that need to be overcome before they become a reality on the roads. Autonomous vehicles were deployed in a number of different settings including for passenger transport, shopping deliveries and for valet parking for residents with mobility issues.
Lola Fernandez-Redondo

Head of Integrated Planning and the Built Environment at DG Cities
Associate Professor at the IE School of Architecture & Design, Madrid