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Towards New Mobility in Barcelona: Lessons Learned from Other Cities

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PPP for CITIES
Specialist Centre on PPP in Smart and Sustainable Cities

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List of Acronyms

E-scooter: Electric Scooter
FFES: Free Floating E-scooter
Free Floating: Without a fixed base, for pick up and drop off
Dockless: Without a fixed base, for pick up and drop off
PMV: Personal Mobility Vehicle
DfT: UK Department for Transport
TfL: Transport for London
AMB: Area Metropolitana de Barcelona (Barcelona Metropolitan Area)
TMB: Transports Metropolitans de Barcelona (Barcelona Metropolitan Transports)
ATM: Autoritat del Transport Metropolità (Metropolitan Transport Authority)

Definitions

Micromobility: Lightweight means of transportation designed for individual use, human powered or electric, operating at speeds typically below 25 km/h. This category includes vehicles such as bicycles, electric bicycles, pedal assisted bicycles, electric scooters, electric skateboards, privately owned or shared[1].

[1] Institute for Transportation & Development Policy, 2021.

1. Executive Summary

City managers face the challenge of solving economic, social, and environmental problems simultaneously, to build more sustainable, equitable, connected and innovative city models that improve the welfare of their residents. In this constant search for improvement, municipal leaders around the world look at the experiences of other cities to get insights and study best practices[1]. Although there is no "one size fits all" solution, this case study aims to help city managers in their endeavors to create innovative mobility models that contribute to creating urban areas that are more environmentally, economically and socially sustainable.

With this objective, we will analyze some of the recent shared e-scooter deployments that have obtained the best results in the main European capitals, so that other cities can build on the most successful approaches and adapt them to their local realities and needs. We seek to contribute to the debate on smart urban mobility models that can promote real change at the local level and improve people's quality of life. In our view, current urban mobility challenges are not only problems to solve, but also great opportunities to exploit.

The scope of this document focuses mainly on the geographical area of the European Union and is organized as follows: in Section II, we are going to provide a brief overview on the agglomeration economies that occur in cities as they grow in density, with positive outcomes such as economies of scale[2] in certain urban infrastructures and transportation, the increase of wealth, talent pool creation and economic impact in cities. At the same time, we will point to the negative externalities that emerge as a result of this growth in density[3]. We will also look at some potential innovative solutions for tackling these externalities. Section III will consider shared e-scooter services as a potential solution to mobility issues, boosting intermodality and reducing the use of private cars. We will also analyze the recent deployment of this service in cities across Europe such as Paris, London and Madrid. Section IV summarizes the lessons learned, best practices and relevant innovations that can be of interest to any other city facing similar challenges now and in the future. Finally, Section V will describe the current situation of the city of Barcelona in terms of governance, sustainability, resilience and adaptation toward climate change and the challenges that it is facing in terms of urban mobility.

[1] Berrone, Ricart Costa, & Duch T-Figueras, 2016.
[2] West, 2016.
[3] Glaeser & Gottlieb, 2009.

2. Background

2.1. Global trends in cities

The world's population will reach 8 billion people in 2030 and 10 billion in 2050[4]. Currently, more than 50 percent of the global population lives in urban areas and 68% will inhabit these in 2050[5]. Rapid urbanization at a global scale exacerbates already familiar challenges that include pollution; environmental degradation; vulnerable housing conditions; urban sprawl; economic inequality; spatial segregation and urban violence, among others[6]. Nevertheless, the benefits of urbanization are still greater than its disadvantages. The cities of the 21st century must guarantee the continuity of human activities while reducing their vulnerability to climate change effects, as well as health and environmental hazards. The European Union's Green Deal centers on fighting climate change through internal policies and international cooperation. EU members have a plan to reduce GHG emissions by more than a 55% by 2030 and become the first carbon-neutral continent to become a resilient society capable to resist climate change in 2050[7]. Wherever we can find an environmental threat, there is an opportunity for improvement, and while modern civilization is damaging resources and ecosystems, cities are already innovating for long-term sustainability.

Today we are re-thinking, designing and building the cities of the future, advocating for technology-based and human-centric smart growth to serve citizens and not the city itself. Urban planners, governments, private companies and citizens must join forces and align to embark on the amazing journey of urban innovation to build the cities of the future. The goals of cities are clear: to enhance the quality of life of their inhabitants, promote economic development and equality, while creating livable, sustainable and vibrant communities.

2.2. Scale and agglomeration economics

Physicist Geoffrey West, pioneer in the field of the complexity science of systems and networks, proved himself to be a visionary when he decided to explore his work's applicability not only to biological organisms, but also to cities and companies. He explained how these behave as complex systems based on networks; therefore, the laws of scalability apply in a similar manner as they do with organisms. His research surprisingly showed that for every doubling in a city's size, in this case of population, the city's need for infrastructure scales sub-linearly, meaning 15% economies of scale in roads, electrical wire and gas stations are needed to support its doubled population. The bigger and denser the city, the bigger the impact on transport, water and energy infrastructure, meaning a 15% reduction on Capex and Opex, construction and maintenance of infrastructures per capita. More amazingly, for every doubling in population size, socio-economic quantities scaled super-linearly, meaning that cities produce 15% increasing returns to scale in wealth indicators, knowledge economy, number of patents, productivity, business diversity and employment indicators per capita, as well as a 15%increase in human interaction speed and supply chain efficiency, among other areas. Unfortunately, this doubling in size of the city also produces a 15% increase in crime, disease, pollution and environmental impact indicators per capita. The larger the city is, the higher the wages, the greater the GDP, the more restaurants created and the more patents issued; however, also the more crime, disease spread speed and other problems[8].

Thus, a city of 10 million people requires 15% less infrastructure and is 15% more productive and socially attractive than two cities of 5 million people each, offering significant savings in materials and energy use. Therefore, the bigger the city is, the more efficient it can become; the greener it is and the smaller its carbon footprint per capita. No wonder cities are growing so fast, posing enormous challenges in terms of sustainability, urban planning, mobility and governance[9].

[4] UN DESA, 2019.
[5] UN DESA, 2018.
[6] Berrone, Ricart Costa, & Duch T-Figueras, 2016.
[7] European Comission, 2021.
[8] West, 2016.
[9] West, 2016.

Economist Edward Glaeser talks about a similar concept, **"agglomeration economics."** These are benefits that emerge when people and companies locate near one another in cities and industrial clusters. He affirms that the denser the city, the higher its productivity due to transport cost savings and the optimization of the exchange of goods, people and ideas, among other factors. Yet while density can have a positive impact on urban success, population, wages, prices and innovation, it can have negative effects on housing prices, for instance, that become higher due to housing supply elasticity.[10] Mobility is a key element for boosting the social and economic development of cities, facilitating access to the job market, product delivery and operation, education, health services, culture, leisure and social activities, therefore, the better and more efficient connectivity and accessibility in cities, the greater the wellbeing of citizens[11].

2.2.1. Negative externalities derived from density and traffic in cities

The car-centric urban planning of recent decades and the urbanization phenomenon have led to a sustained increase in motorization, which contributes to worsening traffic congestion and pollution levels in cities worldwide. The European Union has on average 569 cars per 1,000 inhabitants. Luxembourg has the highest car density with 694 cars per 1,000 citizens, while Latvia has the lowest density, with 342 cars for every 1,000 people. Half of the households in Latvia have no car while more than 31% of the families in France have two[12].

Traffic congestion

Usually, large roads or motorways carrying a huge amount of traffic link directly to the narrower and older network of roads inside city centers with constant intersections and interruptions. This creates a funnel that inevitably causes bottlenecks and traffic congestion as the network cannot cope with the increased volume of traffic. These bottlenecks are accountable for generating traffic congestion 40% of the time, while traffic incidents are the cause 25% of the times, poor signal timing 5%, work zones 10%, and bad weather 15% among other causes[13]. High levels of road congestion produce losses in productivity and economic efficiency that have an important impact[14]. Traffic congestion quantified in Europe represents a cost of 1% of GDP, due to lost time, wasted fuel and the increased cost of doing business[15]. Recent studies have estimated the overall costs of congestion in currency units, finding annual congestion costs as high as $11.7 billion in Paris and $8.5 billion in London in 2013[16]. From a user perspective, the cost of time is also relevant and has a personal cost. The average hours wasted yearly in traffic by individuals in advanced economies on a country level will reach an average of 38.2 hours in 2030, a 6% increase as of 2013, adding the time buffer wasted to counteract the unreliability of car displacements[17].

Air Pollution

Combustion engine vehicles are the major source of air pollution in cities, due to the emission of particles such as $PM_{2.5}$ and NO_2, and one of the leading environmental causes of morbidity and mortality worldwide. About 84% of European citizens regularly suffer from pollution levels above the maximum recommended[18]. According to some estimates, the world's 724 largest cities could reduce GHG emissions by up to 1.5 billion tons of CO_2 annually by 2030 primarily through changes in transportation systems[19]. In this regard, cities are making noteworthy improvements in relation to bettering transport efficiency. Private companies are designing new eco-friendly vehicles and new business models that are contributing to changing the transportation ecosystem in cities.

[10] Glaeser & Gottlieb, 2009.
[11] Berrone, Ricart Costa, & Duch T-Figueras, 2016.
[12] European Automobile Manufacturers Association, 2019.
[13] Kivilcim, *et al.,* 2016.
[14] Berrone, Ricart Costa, & Duch T-Figueras, 2016
[15] Thomson & Bull, 2002.
[16] CEBR, 2014.
[17] CEBR, 2014.
[18] World Health Organization, 2014.
[19] Global Comission on the Economy and Climate, 2014.

Table 1. Top 5 European Cities With the Highest Mortality Burden Due to Air Pollution

Position on ranking	PM2.5	NO2
1	Brescia, Italy	Madrid, Spain
2	Bergamo, Italy	Antwerp, Belgium
3	Karvinà, Czech Republic	Torino, Italy
4	Vicenza, Italy	Paris, France
5	Silesian Metropolis, Poland	Milan, Italy

Source: Prepared by the authors based on IS Global Ranking of Cities by ISGlobal.

A recent report stated that daily air quality measurements in April 2020 (during the COVID-19 pandemic) showed a decrease in CO_2 levels of 17% globally, as compared to mean 2019 levels, and 31.9% in Spain, the highest decrease percentage in Europe[20]. The main source of this decrease in pollution levels came from the removal of cars from the streets due to forced movement restrictions, which also reduced noise levels dramatically. These empty streets gave citizens a hint of what a city could feel like with fewer cars and more free space to enjoy with cleaner air and less environmental noise.

Noise Pollution

Excessive road traffic also causes noise pollution, defined by the World Health Organization as noise above 65 decibels. In urban environments, this affects the hearing capabilities of citizens and produces health problems. The "average hearing loss index" has a 64% positive correlation with noise pollution levels in cities, indicating that hearing loss may be an outcome of living those areas. According to a recent study, two European cities rank among the 10 with worse noise pollution worldwide, Barcelona ranking seventh and Paris ninth. According to this study, the average city dweller has a hearing loss of a person 10-20 years older than their actual age[21].

Lack of public green open spaces

The global increase in population and urbanization has led to a progressive reduction in green open spaces available in cities. This diminished network of green spaces within or near the city has an impact on the physical, mental health and wellbeing of inhabitants and on urban ecosystems. Public open space confers physical benefits to people including encouragement to perform physical activity, facilitation of social interaction[22], and the regulation of city temperatures[23]. Increases in exposure to green spaces could prevent many premature deaths in European cities, while contributing toward making them healthier and more sustainable[24]. These benefits are significant, given that approximately 75% of the population in Europe lives in urban environments[25].

According to the WHO, each resident should have access to a green space within a 300-meter distance of their home[26]. However, although it is necessary for the wellbeing of city dwellers, public space in cities has become a scarce good because the parking and circulation of vehicles are currently prioritized. Today, cars instead of pedestrians use an average of 75% of the public space in our cities while they remain parked and inactive 95% of the time[27]. According to a recent study, following the recommendations of the WHO on universal access to green spaces for citizens could decrease early mortality in 978 cities and 49 greater cities across 31 European countries[28]. An example is Barcelona, where the implementation of the Superblocks Program led to an increase of green spaces from 6.5% to 19.6%, and has prevented 60 premature deaths annually in the local neighborhood[29].

[20] Le Quére, *et al.*, 2020.
[21] Mimi Hearing Technologies, 2017.
[22] Javad Koohsari, Badland, & Giles-Corti, 2013.
[23] Villanueva, *et al.*, 2015.
[24] Pereira, *et al.*, 2021.
[25] WHO, 2018.
[26] WHO, 2016.
[27] Ahsanul Habib & Jahedul Alam, 2018.
[28] Pereira, et al., 2021.
[29] Mueller, *et al.*, 2020.

2.3. Urban mobility drivers

Today, three central elements are driving the developments in urban mobility. First, the rising demand for urban mobility due to the unprecedented increase in urban population. Currently, 10 billion trips take place in urban areas globally every day, 64% of all travel made. This increase in demand for urban mobility is putting increasing pressure on the current infrastructure of cities, with the total number of urban kilometers travelled worldwide projected to triple by 2050[30].

The second driver is the change in the preferences and behavior patterns of citizens seeking more convenient mobility options. A survey by Deloitte found that Generation Y, or Millennials, are more interested in alternative modes of transportation such as shared mobility services than personal vehicles, unlike the previous Baby Boomer generation[31]. Moreover, citizens are becoming increasingly concerned about climate change and their environmental urban footprint and therefore demanding greener and more sustainable mobility options[32].

The third driver is the advance of new technologies, devices, platforms and business models that are quickly disrupting existing urban transportation systems. The convergence of smartphones, Geo Positioning Systems (GPS) and updated network maps have permitted real time and updated transport information. This real time information is boosting shared mobility trips that are multi-modal, as well as the development of new business models and ways to move around in cities[33].

2.4. Solutions to improve urban mobility

The European Green Deal has the ambitious goal to reduce greenhouse gas emissions produced by the transport sector by 90% in 2050. The European Commission has designed several strategies to meet this goal and create a new, clean, modern and digital transport sector. Key objectives are the adoption of zero-emission vehicles, the increase of available alternative transport solutions, digitalization, automation, and connectivity[34]. Within this framework, **micromobility** has taken off and Personal Mobility Vehicles (PMV) – both mechanical and electrical, privately owned and shared – are growing in demand and have the potential to lead urban mobility towards cleaner, sustainable, and more equitable transport solutions[35].

The sharing economy

New consumer habits, along with increasing environmental awareness, are accelerating the adoption of the sharing economy[36]. The mobility sector has been significantly impacted by the sharing economy, as younger generations are leading the transition **from being the owners of a vehicle to being the users of a mobility service**. The shared mobility sector has quickly turned into one of the fastest-growing segments within the sharing economy. The global shared mobility market was expected to reach annual growth rates between 20% and 35% between 2013 and 2020[37].

Influenced by these urban mobility drivers, digital personal mobility services are offering profitable opportunities through the creation of adaptable and flexible business models powered by technologies that facilitate information for customers on vehicle availability and fleet management. The perception of the user is that of a convenient, comfortable and accessible service that brings about positive externalities for the city, such as less traffic congestion, a complement to public transportation and last-mile delivery services, the improvement of air and noise pollution levels, and lower greenhouse gas emissions[38].

[30] Rode, *et al.,* 2014.
[31] Deloitte, 2014.
[32] Deloitte, 2014.
[33] Berrone, Ricart Costa, & Duch T-Figueras, 2016.
[34] European Commission, 2020.
[35] Dias, Arsenio, & Ribeiro, 2021.
[36] Cohen & Kietzmann, 2014.
[37] Freese & Schönberg, 2014.
[38] Franca, Ricart, & Berrone, 2020.

Most daily activities performed within the urban environment can be done by micromobility trips[39]. In these sorts of short trips, traditional public transportation is not efficient since in many countries it usually offers flat rates that are not in direct proportion to the length of the trips. This inefficiency prevents some citizens to use public transportation and choose to walk instead. Shared mobility, particularly shared bicycles and e-scooters, can offer an intermediate solution in the micromobility trips arena by providing users with a faster, more convenient, predictable and efficient means of transportation at a smaller cost than traditional public transportation. Shared mobility, if extended sufficiently, offers an attractive alternative to public transportation, when the latter is perhaps inefficient or has a limited schedule.

Starting with shared bicycles

Most European cities have dense populations, a fair amount of bike lanes, and high bicycle ownership levels. As an example, 90% of the population in Denmark owns a bike, 38% of Danish commute daily by bike, while just 53% of households own a car[40]. European cities have been pioneers in offering shared public bicycle services. An example is La Rochelle, France, which in 1974 launched a bike-sharing service that is still working today[41]. The "Vélib Métropole" of Paris, launched in 2007, is a leading bike-sharing service created with the goal to promote new mobility in the Greater Paris Area. In 2020, the service had 400,000 subscribers, surpassing a record of 5.5 million journeys made in one single month in September. On the 11th of that month, it reached a record of 215,000 journeys made in a single day[42].

The number of bike-sharing systems worldwide grew from just 11 in 2004 to over 1,000 in 2017, in more than 50 countries[43]. This links to the development of the digitally based shared mobility industry: between 2014 and 2018, the sector attracted over US$ 5.7 billion in investments and is expected to be worth between $200 and $300 billion by 2030[44]. However, this figure does not include existing public systems for shared mobility, which to a degree, complement and compete with private initiatives[45].

Mobility as a Service (MaaS) and intermodality

Economic changes and current trends point to a rise in subscription models for the renting of goods, shifting away from ownership. MaaS represents a way of managing the mobility ecosystem and benefitting the user via a digital platform that can regroup different modes of transportation, unify forms of payment and facilitate access to the user. Providing users with an effective intermodal system, and an intuitive, clear and easy way to use platform, would also encourage further adoption of public transport, which would lead to a decrease in the use of personal vehicles. MaaS is not exempt of its own challenges. The first is related to implementation, as MaaS requires an intense cooperation between the different companies that are responsible for each mode of transport available at the platform. Frequently these companies are both private and public, which can also involve a convergence of interests between the private (such as ride-sharing companies) and public sectors. Private companies can be more volatile than public ones and potentially disrupt modal integration in the case of modifications, bankruptcy or simply exiting the business. Thus, the challenge of MaaS implementation is as much a challenge of institutional cooperation and public policy as it is of software design[46].

MaaS fosters a new governance structure for public subsidies into mobility and a transition from highly inefficient gross service contracts to data-driven, trip-based, results-oriented subsidies. As users make use of a mobility platform to book and use a shared vehicle service, or other means of transport (public and private), they produce lots of data. Public and more often private companies need the right incentives to open their data, but they are often willing to do so in the framework of a mutually beneficial Public-Private Partnership model towards the realization of Maas. This shared data serves the city and helps mobility operators improve their competitiveness and the efficiency of their operations[47].

[39] Micromobility trips are considered as those under 8 kilometers according to the US National Household Travel.
[40] Urban Life Copenhagen, 2021.
[41] CBINSIGHTS, 2018.
[42] Vélib Métropole, 2020.
[43] Goodall, Dovey, Bornstein, & Bonthron, 2017.
[44] CBINSIGHTS, 2018.
[45] Franca, Ricart, & Berrone, 2020.
[46] Franca, Ricart, & Berrone, 2020.
[47] Laborda, 2021.

3. Shared e-scooters as a practical solution

E-scooters offer a practical solution to urban mobility, as they are unipersonal, convenient and a zero-emissions means of transport. In recent years, this micro-mobility alternative to cars has attracted a lot of attention because of its potential to disrupt transportation. E-scooter sharing has gained as many followers as detractors and has spread rapidly in cities around the world, transforming traffic and challenging mobility planning. **E-scooters can lead urban mobility towards cleaner, sustainable and a more equitable transport solution[48]**. However, most local authorities still struggle to integrate shared e-scooter services efficiently in their transport systems and the exact impact of this means of transportation remains unclear. In this report, we will focus on the lessons obtained to date on the deployment of this sharing service in major cities across Europe.

3.1. Pioneer deployments in Europe

Rental e-scooters services were first launched in Europe in 2017 and adoption spread fast. Free Floating E-Scooters (FFES) or shared electric scooters without a designated station (also called dockless e-scooters) quickly became popular because they offered a convenient way to make short-distance trips in urban areas[49].

Benefits

The benefits initially expected from shared e-scooters in cities included: less traffic congestion, less air and noise pollution lower GHG emissions, and fewer cars on city streets. Nevertheless, local authorities are still measuring the real impacts[50]. The small space e-scooters occupy when operating and parking as well as their speed, have the potential to improve transportation issues faced by most European cities and potentially become a feasible alternative to cars in urban trips[51]. During and after the coronavirus lockdowns, people sought out safe alternatives for getting around the city, avoiding cars due to their inherent features that do not enable social distancing. Privately owned and shared e-scooters became the alternative for making many trips.

Some of the main benefits arising from early deployments were:

- No air pollution.
- No noise pollution. As an example, a motorbike crossing Paris at night can wake up 2,000 people, while an e-scooter is silent.
- Space use optimization as e-scooters have a small parking footprint: within a single car parking space, you can fit up to 8 bikes and 16 e-scooters.
- Accessibility and low barriers to entry.

Early drawbacks and concerns

Users were excited to embrace this new service, but due to the novelty of the situation and the correspondent lack of regulation and supervision, soon enough the consequences of irresponsible and unregulated use became a constant struggle for cities. Additional concerns emerged over the business strategies of shared mobility providers, who were accused of a “shoot first” approach of deploying many scooters in cities, foregoing public debate, and generating large amounts of clutter. Other concerns include user safety, regulations and whether these private service providers should be responsible for enforcing them[52]. Most cities have been adapting through trial and error and are still building a common and appropriate legal framework while responsible operators and good practices are becoming the future of the industry.

[48] Dias, Arsenio, & Ribeiro, 2021.
[49] Hosseinzadeh, Algomaiah, Kluger, & Li, 2021.
[50] Gössling, 2020.
[51] Hardt & Bogenberger, 2019.
[52] Franca, Ricart, & Berrone, 2020.

Figure 1. Example of Street Clutter Due to Incorrect Parking of E-Scooters in Cologne, Germany 2019

Source: Photo by Mika Baumeister on Unsplash.com

Some of the main issues arising from early deployments were:

- Street clutter. Circulation and spatial conflict with other transport and pedestrians.
- Absence of planned parking hubs.
- Absence of a common legal framework to define and sanction bad practices.
- No integration of public and private mobility to promote multimodality.
- No responsibility from operators.
- No data-sharing framework between operators and the city.

Lessons learned

City planners agreed on the need to adapt and decide on objectives, measures and policies regarding key issues such as maximum speeds, mandatory use of cycling dedicated infrastructure, dedication of designated parking spaces for picking and dropping off or limiting the number of operators and vehicles[53]. The power and speed of e-scooters can create dangerous risks of accidents if they share space with pedestrians or cyclists going at lower speeds. Most cities' bicycle lanes and infrastructure do not yet reflect these changes in urban mobility. They seek to raise awareness with a priority on protecting pedestrians and cyclists[54]. The expertise, predisposition and cooperation of responsible operators such as Dott are key for improving the situation.

What should be the next steps?

- Create a solid Public-Private-Partnership structure to build a common framework.
- Build a dense and connected network of dedicated parking spots for e-scooters.
- Define strict user regulations for parking and security.
- Address observed user preferences such as the need for density and availability of the service.
- Set and track clear hardware quality and align with defined policy objectives (vision zero, emission targets, social agenda, etc.) for operators.
- Use data gathered from operators to improve the service for users and the city.

[53] Gössling, 2020.
[54] Zargoskas & Burinskiené, 2020.

3.1.1. Paris

Table 2. Paris Data

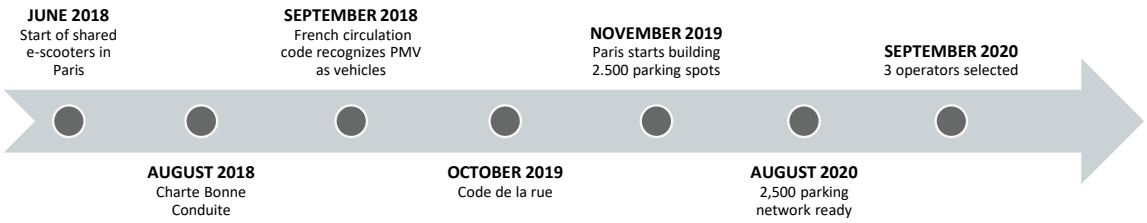
PARIS, FRANCE	2020
Population City of Paris	2,273,305 inhabitants
Density	21,258 inhab./km^2
Extension	105.4 km^2
Number of districts (Arrondissements)	20
Tender / Authorization	Public contract 2020 – Duration 2 years
Number of operators	3 (Lime, Tier, Dott)
Number of shared e-scooters	15,000 (5,000 per operator)
Number of dedicated parking spaces	2,500

Source: Prepared by the authors based on Wikipedia.

Background

Undoubtedly, Paris is the most advanced city in Europe in terms of micro-mobility and was one of the pioneers in experiencing the booming and rapid expansion of privately owned micro-vehicles and Free-Floating E-scooters (FFES) on its streets. By 2018, e-scooters had already become bestsellers in the market category of micro-vehicles, a 129% increase in volume compared to 2017 while non-electric scooter sales had decreased by 20%[55]. In June 2018, a week after launching operations in Zurich, Switzerland, with 150 e-scooters, the San Francisco-based company Lime started operations in the 1st and 6th districts of the center of Paris with a few hundred electric scooters and the expectation to increase the fleet to thousands in the near future[56]. Three months later, France's Minister of Transport announced that "e-scooters" had become a new vehicle category recognized in the French traffic code, and that future mobility legislation would provide a legal framework for "free floating" vehicles[57]. Demand kept growing and the city soon had opened the door for up to 12 new companies that started operating with total freedom.

Figure 2. Shared E-scooter Deployment Timeline in Paris



Source: Prepared by the authors.

Emerging problems

The number of FFES had grown fast from the first few hundred vehicles to about 30,000 low-quality and short lifespan e-scooters deployed in the city before completing one year of operations[58]. Self-employed workers oversaw the fleet management with no actual responsibility or supervision from the operators, which did not guarantee a proper service to the city[59]. At that point, the situation on the streets of Paris had become unbearable and uncontrollable, with issues such as e-scooters being driven

[55] Fédération des Professionnels de la Micro-Mobilité, 2018.
[56] Le Monde.fr, 2018.
[57] Le Monde.fr, 2018.
[58] Le Monde.fr, 2019.
[59] Dott, 2020.

on the sidewalks; speed limits being exceeded, putting pedestrians and vulnerable population at risk; the creation of street clutter; and problems of coexistence with other means of transportation. The actual risk of collision with pedestrians was real; therefore, the challenge was for public space to find a way to remain safe for all users and get all the different modes of transport to coexist peacefully[60].

City authorities had not foreseen the potential issues that could arise and so they did not have a plan to react immediately. They also lacked a regulatory framework and a strong collaboration relationship with the operators. Nevertheless, they soon detected that parking was the most urgent matter to tackle in early 2019, as 65% of the users parked on the footways at the end of their trips, filling the streets with clutter and getting in the way of pedestrians[61]. The main reason for incorrect parking was the absence of a planned network of parking hubs specifically designated to serve this purpose and the lack of regulations or a legal framework to encourage parking compliance and to sanction bad practices.

Solutions

Creation of work groups for public–private collaboration

To address these matters, the City of Paris and the operators created work groups to share information, knowledge and exchange feedback on the ongoing operations. This collaboration helped figure out a way to align the objectives of all the stakeholders involved: the city, the operators and the end users. As a result, in May 2019, the city of Paris published the first version of the Code of Good Conduct (see **Exhibit 1**) signed by the Paris City Hall and the operators to get their commitment to place the necessary control measures to make shared e-scooters sustainable and regulated. The charter included a regulatory framework on parking and circulation; commitment from the operators on security and deployment; terms of relationship with the City Hall; sustainability; and data exchange in accordance with France's new mobility law (Loi d'orientation des mobilités, LOM) came into effect in December 2019.

These work groups fostered direct communication and regular information exchanges to detect the main concerns and objectives of each stakeholder and put in place the right strategies to achieve balance among them. Local authorities cared about user safety, street clutter, conflict with pedestrians and other means of transport, intermodality, public space use, correct parking and circulation, sustainability, and professionally managed operations to guarantee homogeneity in parking in distribution. For the end user, the main concerns were security and comfort of the trip, the possibility to save time by traveling from door to door, service reliability, and vehicle availability within a two-minute walking distance. Operators were concerned about providing the end user a quality and efficient service through a dense and connected parking network, regulations, efficient vehicle charging, and fleet management, while being part of a profitable market in terms of competition, scalability and adaptability to demand[62].

Leveraging car parking to build a dense and connected network of e-scooter hubs

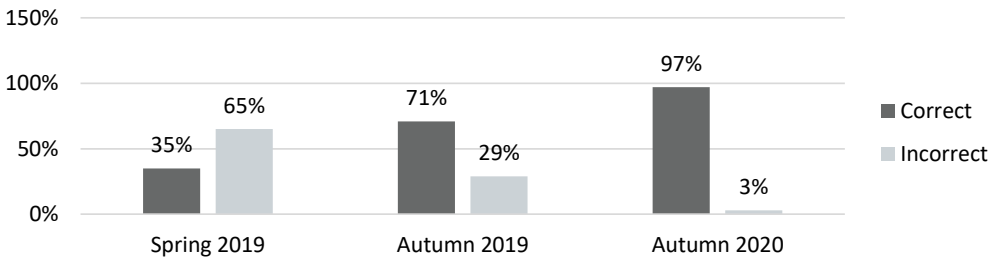
Due to long-term car-centric urban planning, most cities seem meant to be driven instead of walked or cycled. They look like huge parking lots, accommodating cars instead of people marginalizing non-driving citizens, promoting a sedentary lifestyle, causing health problems and unbearable traffic congestion for everyone. Moreover, these negative effects are unfair to non-drivers. There is ongoing debate about car parking on streets, since most cities offer this for free regardless of the costs to the city. These costs are also paid indirectly by citizens who do not own a vehicle but whose taxes are spent on building and maintaining car parking spaces that they do not use[63]. The working groups of stakeholders in Paris identified car street parking as a win-win opportunity for accommodating parking hubs for shared e-scooters. Several studies and surveys mandated by Dott contributed to mapping user behavior and preferences to give further insight on the issue of parking in terms of density, usage and location with the understanding of users, their transportation patterns, needs and priorities.

[60] Mairie de Paris, 2019.
[61] 6t / Momentum Transport Consultancy, 2020.
[62] 6t / Momentum Transport Consultancy, 2020.
[63] Shoup, 2005.

With strong political leadership supporting micro-mobility parking and the gathered information from users and operators, such as Dott, the City of Paris built a dense and connected mandatory parking network dedicated exclusively to shared e-scooters licensed operators. The network, built between November 2019 and August 2020, consisted of 2,500 parking hubs in 81 km^2 (density of 31 hubs/km^2), each replacing a surface car-parking slot, with a total capacity of 15,000 e-scooters shared by all the operators. The hubs were on average 150 meters from each other, equivalent to a two-minute walk, and had the capacity for six e-scooters. The operator's geo-located apps marked the available spots and communicated the parking rules to users. The city invested in painting the designated parking hubs with pictograms, while the tax per scooter, paid by the operators for the use they made of public space, covered maintenance investments.

Paris soon observed an improvement in the parking behavior of end users (see **Figure 3**). This parking network helped to meet the expectations and preferences of users who perceived the service as reliable, convenient and time saving, allowing them to make trips from door to door with a high availability of safe and comfortable vehicles. Users had to validate parking on a geo-located hub via photo. Incorrect parking incurred a fee of €10 to the user[64].

Figure 3. Evolution of Parking Compliance Among Shared E-scooter Users Over Time in Paris



Source: Prepared by the authors based on data provided by Dott.

Licensing operators

After France's new mobility law, LOI n° 2019-1428 du 24 décembre 2019 d'orientation des mobilités, was published[65], the city of Paris decided to open a tender for a maximum of four authorized companies and a maximum number of vehicles per operator[66]. Paris launched the bidding process to select this limited number of suitable operators with three selection criteria in mind. The first was user safety, weighing 30% in the decision. This referred to the reliability of the hardware, respect of the road code, accident prevention, private data protection and insurance. The second criteria, with a weight of 30%, included fleet management, vehicle maintenance, guarantee of parking compliance and vehicle recharging. The third criteria, with a weight of 40% in the decision, was the environmental responsibility of the operators in terms of hardware, maintenance, engine durability, energetic performance, use of renewable energy for operations, security of charging stations, recycling, sustainability of the management fleets and capability for multimodal integration[67]. In September 2020, Dott won the public tender of the Paris City Council together with Lime and Tier, in part, thanks to their idea of taking the scooters off the sidewalks and parking them exclusively on the road. Operators paid a fee of 50€/e-scooter/year as a contribution to the city's investment in parking infrastructure building and maintenance and their use of public space.

Establishing safety, quality and environmental criteria for vehicles and operators

To guarantee the city priority of user safety, operators were required to deploy high quality and reliable vehicles with the ultimate security features, compliant with French and European safety regulations EN 14619: 2019 and thoroughly revised on a regular basis. Operators had to facilitate the necessary

[64] Dott, 2020.
[65] Government de France, 2021.
[66] de Bortoli & Christoforou, 2020.
[67] Paris, 2020.

means to ensure user compliance with circulation and parking regulations through their apps and platforms and promote user education for accident prevention. Complete control of operations and parking management was key to ensure the quality and reliability of the service. The operation teams had to comprise 100% in-house employees, with 100% responsibility of the management of all vehicles in circulation without any kind of outsourcing allowed. To minimize conflict with pedestrians and street clutter, the fleet management teams worked to avoid hub saturation and clutter; keep the necessary maintenance and management of non-functional, damaged, or inactive vehicles; and to identify, prevent and remove wrongly parked vehicles. In addition, operators such as Dott, assumed the environmental impact of the operations in the city and a responsibility for reducing it. To be more sustainable, operators committed to the use of a zero-emission vehicle fleet, maximizing the durability and energetic efficiency of the fleet, and taking the necessary measures to provide environmentally and professionally secure charging centers. Operators had to establish recycling and waste treatment programs to treat residues, especially batteries. The supply of electricity in the facilities had to come preferably from renewable sources[68].

Lessons learned

Some of the elements that have been key to protect the use of public space, while guaranteeing a high availability service by building a well-distributed fleet and a dense parking hub network throughout the 17 districts of the city of Paris, are:

- Maintain a regular dialogue among stakeholders.
- Control fleet and parking management by operators 100% in house.
- Limit the number of licensed operators and vehicles.
- Ensure a sustainable business for operators.
- Share operators' data with the authorities to turn it into useful insights for the city.
- Guarantee data protection and user privacy.

The improvement in parking compliance shows that appropriate city planning; regulation and infrastructure management by local authorities, good operation practices, dialogue and data exchange among stakeholders can lead to a minimization of the externalities produced by urban micro-mobility and therefore can be extrapolated to deployments of such services in other cities.

It is crucial to establish a "committee" to lead the public-private collaboration, agreements and dialogue before launching the service and co-design every element of the system to find an acceptable formula that works for each stakeholder.

3.1.2. London

Table 3. London Data

LONDON, UK	2020
Population City of London	8,961,989 inhabitants
Density	5,666 inhab/km^2
Extension	1,575 km^2
Number of districts (Boroughs)	33 (10 participating in e-scooter trial)
Tender / Authorization	Public contract 2021 – 18-month trial
Number of operators	3 (Dott, Lime, Tier)
Number of shared e-scooters	3,585 (1,195 e-scooters per operator)
Number of dedicated parking spaces	400

Source: Prepared by the authors data Wikipedia.

[68] Dott, 2020.

Background

After the COVID-19 pandemic lockdowns, people were looking for new ways to travel through the UK. The government wanted to provide citizens with a "green restart of local transport" through green, effective, safe, and sustainable mobility alternatives to private cars. Initiatives such as boosting cycling and walking to reduce crowding on public transport by building new bike lanes and launching trials of rental e-scooters to increase transportation options had been carried out. The implementation of Mobility as a Service (MaaS) was already a priority for the UK government, which wanted to lead the development of MaaS platforms with local authority leadership by launching controlled trials in local areas across the country, including London[69]. In July 2020, the UK Department for Transport launched "The Future of Transport Regulatory Review" to find answers to current questions about transport regulation to ensure a flexible, inclusive and future-proof regulatory framework that could tackle priorities such as micromobility and Mobility as a Service. Questions and analysis on the legalization of micromobility vehicles and trials of rental e-scooters were put to discussion[70].

The need to remove pressure from public transport was a key factor to move the e-scooter trials forward in more areas than initially planned. The e-scooter operators would be required to work hand-in-hand with local authorities to replicate similar rental schemes that had already taken place in other countries. The main goal was to deploy safe and controlled trials to gather insightful data to build this service in the future. Only selected operators would be allowed in the trials and privately owned e-scooters would remain illegal to use on roads, bike lanes and pavements[71].

The London Trial in 2021

On June 7, 2021, London's trial of rental e-scooters started with Transport for London (TfL) as the leader with permission from the UK's Department for Transport (DfT) for trial schemes to be developed by regional and local authorities[72]. After a competitive process, three operators – Dott, Lime and TIER – were selected from 16 applicants and allowed to deploy an initial fleet of 600 e-scooters, which has grown to over 3,000 as new boroughs joined the trial, and more parking has become available. The three companies were selected because of their ability to meet strict safety requirements and high operating standards. These operators could apply previous experience and know-how gained from successful deployments in other major cities to ensure that the e-scooter trial in London became a success, not just for riders, but also for other road users and the community.

Some of the goals of this trial were:

- To support the air pollution goals of the city.
- To reduce noise pollution.
- To connect historically underserved boroughs.
- To address equity concerns highlighted by the differences in user demographics for private and shared e-scooters resulting from fleet availability and low approved parking density in lower income areas.

Public-private collaboration to design the trial

The trial was prepared in collaboration among London Councils, the Boroughs, Transport for London, TfL's Independent Disability Advisory Group, and the three e-scooter operators selected for the trial. This collaboration was key to ensure the trial would meet shared objectives. The operators would continuously share the data gathered by their apps to help build a better strategy for the shared e-scooters in the future, always in compliance with personal data protection policies. The London shared e-scooter trial would not cover the use of privately owned e-scooters on public roads, and this remains illegal in the UK, as does riding any e-scooter, rental or private, on footways. The Metropolitan Police is also taking an active part of the trial development also making sure that privately owned

[69] UK Department for Transport, 2020.
[70] UK Department for Transport, 2020.
[71] UK Department for Transport, 2020.
[72] Safe Travel Camden, 2021.

e-scooters are not being used during the trial[73]. Therefore, the only way to legally ride an e-scooter in London is by using one of the three shared e-scooter services in a limited number of London boroughs[74]. Ealing, Hammersmith & Fulham, Kensington & Chelsea, Richmond, Tower Hamlets (including Canary Wharf), City of London, Lambeth, Southwark and Westminster are already part of the trial, with Camden as the latest addition in late September 2021[75]. More boroughs are currently seeking participation as the trial goes on and some are only "ride-through areas," where users may travel through but not start or end e-scooter rides[76]. Some are expanding to offer e-bikes as well.

The main concern of this trial is the safety of pedestrians, riders and other road users. To ensure a safe trial, restrictions beyond national standards reinforce safety regulations and legislation. Inspired by the success of the deployment in Paris, riding is allowed in cycle lanes and cycle paths and parking is restricted to 400 designated parking hubs shared by the three operators (see **Figure 4**) throughout the different participating boroughs[77]. When a trip is finished, the user is required to park the e-scooter within a geo-located designated spot. Parking hubs are preferably located on roads rather than motor vehicle surface parking spaces, allowing the next user to find an e-scooter on a designated hub. Providing these designated parking hubs prevents street clutter.

To gather valuable real-time information, monitor, adapt, make long-term recommendations and understand the real impact produced by the trial in the city, users were encouraged to give their feedback. Anyone taking part in the trial is welcome to give his or her feedback and specific demands through an interactive map provided by Transport for London in the Trial web portal. The main topics of interest were parking network effectivity, parking compliance, rider behavior and experience, safety perception, quality of the road, potential conflict with other users of the public space, and need of further protection[78].

Early feedback of the trial

During the first four weeks of the trial, operators reported 35,000 trips made on their shared e-scooters. The average distance traveled was about 2.9 km[79]. Dott noticed that London riders made trips of an average duration of 21 minutes, which was considered a long time in comparison to other cities. For example, users in Paris used the service mainly to perform door-to-door trips that otherwise they would have walked and lasted an average of 15 minutes. This early data suggests that the rides are not just replacing walking trips but are creating new trips to move people over significantly longer distances. After three months of launching the service, Dott's app had already registered 60,000 journeys on its e-scooters assuming an average of about 400 e-scooters across the three-month period. It featured a quite low utilization of less than two journeys per scooter per day. The same operator registered 400,000 journeys per month with a fleet of 5,000 e-scooters, meaning a utilization of 2.5 journeys per scooter per day in Paris.

[73] Safe Travel Camden, 2021.
[74] Transport For London, 2021.
[75] Dodds, 2021.
[76] Transport For London, 2021.
[77] Transport For London, 2021.
[78] Transport For London, 2021.
[79] Hutton, 2021.

Figure 4. Designated Parking for Shared E-scooters in London Trial 2021

Source: Picture provided by Dott.

The lower utilization rates in London are due to the launch of the service in three quite disconnected areas and not in the center of London, and a lack of parking. Now the areas are connected and the key central London boroughs are all participating. In terms of parking network and compliance, Dott reported that 94% of the journeys ended at a designated parking hub while the remaining 6% ended around the edge of borough boundaries that cannot be crossed. This will improve as more boroughs are added to the trial and more parking hubs are made available to the network. London has only 400 parking hubs – far fewer than Paris, which has 2,500[80]. In terms of density, London has Circa3 bays per km^2 of operating area, while Paris has Circa 30 bays per km^2 of operating area.

The main feedback from the London trial is that dedicated parking works (high parking compliance, zero serious safety incidents for pedestrians) but only if there is appropriate density. The lack of parking density and availability is kneecapping the trial and preventing it from meeting its own objectives.

Figure 5. Shared E-scooters in London Trial June 2021

Source: Provided by Dott.

[80] O'Brien, 2021.

Table 4. London E-scooter Rental Trial Headline Metrics

	Trial Period 1	Trial Period 2	Trial Period 3	Trial Period 4	Trial Period 5	Trial Period 6	Trial Period 7	Trial Period 8	Trial Period 9	Total / Average
Dates[1]	07 Jun 04 Jul 2021	05 Jul 01 Aug 2021	02 Aug 29 Aug 2021	30 Aug 26 Sep 2021	27 Sep 24 Oct 2021	25 Oct 21 Nov 2021	22 Nov 19 Dec 2021	20 Dec 2021 16 Jun 2022	17 Jan 13 Feb 2022	
Permitted fleet size[2]	600	1.200	2.700	2.835	3.480	3.585	3.585	3.585		
Total trips[3]	35.000	50.000	80.000	95.000	100.000	95.000	75.000	65.000	75.000	660.000
Average trip distance	2.9 km	2.7 km	2.8 km	2.8 km	2.5 km	2.5 km	2.4 km	2.6 km	2.4 km	2.6 km
Average trip duration	24 min.	22 min.	21 min.	22 min.	18 min.	18 min.	17 min.	19 min.	16 min.	20 min.
Serious injuries reported by operators[4]	1	2	2	1	3	0	4	1	1	15

[1] The trial is being managed using 4-weekly trial periods and started June 2021.

[2] Maximum fleet size determined by TFL, the London City Council and the Boroughs of London and is periodically reviewed.

[3] Number provided by the operators.

[4] Reported to Transport for London by the operators.

Source: Prepared by the authors based on (Transport For London, 2022).

3.2. The shared e-scooter ecosystem in Spain

The use of Personal Mobility Vehicles in Spain is apparently less than expected, since citizens still choose different means of transport for their urban trips. Shared mobility services are used more than twice a week by 3.55% of Spanish population, while 58% prefer to walk, 53% use public transportation and still 34% keep using their private cars[81]. Spanish citizens perceive e-scooters as a means of transport related to leisure and not as safe as bikes[82].

Regulation on a national level regarding e-scooters. The General Directorate of Traffic (DGT) announced on early 2021 concrete measures on the use of e-scooters, considering them to be Personal Mobility Vehicles (PMV). Therefore, according to the traffic legislation in force, they are prohibited from traveling on sidewalks, as well as on interurban roads, crossings, highways or urban tunnels. E-scooters, as part of the PMV category, are forbidden to cycle at more than 25 kilometers per hour and drivers are required to hold insurance. These measures had intuitively been already put into practice by most city councils. However, each municipality must individually set its own regulations to manage operators since there is no common regulatory framework on a national level on this matter[83].

[81] Zargoskas & Burinskiené, 2020.
[82] Sellaouti, Arslan, & Hoffmann, 2020.
[83] Rodríguez A., 2021.

3.2.1. Madrid

Table 5. Madrid Data

MADRID, SPAIN	2020
Population City of Madrid	3,334,730 inhabitants
Density	5,418,47 inhab./ km^2
Extension	604.3 km^2
Number of districts	21
Tender / Authorization	Authorization
Number of operators	14 authorized, only 4 operating
Number of shared e-scooters	8,610 e-scooters deployed (Maximum 10.000)
Number of dedicated parking spaces	0

Source: Prepared by the authors based on Wikipedia.

Background

On the streets of Madrid there are approximately 5,000 shared e-scooters managed by more than four different companies and distributed along the 21 city districts of the city. These operators are required by the City Council to have geolocation and an insurance for drivers and third parties with a minimum coverage of €1 million. In addition, they must redistribute all their vehicles daily and start the day in the neighborhoods for which they have obtained authorization.

Regulation and parking

The use e-scooters, part of the category of so-called Personal Mobility Vehicles (PMV), is regulated by the Sustainable Mobility Ordinance in force in the city of Madrid detailed in **Exhibit 2**. In terms of parking, Madrid does not dispose of a network of parking spaces designated for this service. E-scooters should preferably be parked in any space indicated for motorcycles and bicycle parking, and if not available, they are allowed to park in the general parking area of the road. Exceptionally, it is also possible to park them on the sidewalks if the e-scooter does not hinder pedestrian traffic and people with reduced mobility. The controllers of the Regulated Parking Service have jurisdiction to sanction e-scooters that violate current regulations for parking in improper places (this type of vehicle is not obliged to pay the Regulated Parking Service fees). The penalties for misuse and non-compliance with the regulations are imposed based on the Circulation Code and the municipal police officers, the mobility agents and the regulated parking service of the city of Madrid oversee their compliance[84]. It is not allowed to anchor e-scooters with anti-theft chains or padlocks on furniture or objects on public roads such as traffic lights, benches, trees, bus shelters or fences. With the aim of freeing up the sidewalks and guaranteeing global accessibility in all pedestrian areas, new reserved space has been created for the parking of bicycles and scooters on the road[85].

The authorization system for operators

Currently, the shared e-scooter service in Madrid works through a system of temporary public authorizations for the special use they make of the municipal public domain. The origin of these authorizations' dates from October 2018, and their modification had been extended to November 2021, but it is in the plans of the City Council to publish a new authorization model. This new model would most likely limit the number of operating companies. Selection criteria of operators based on the level of hardware technology and its capabilities could be applied to improve traffic safety and compliance with current regulations. In the new system for regulating the service of shared e-scooters without a fixed base, a network of car parks would be established for this purpose to avoid uncontrolled parking of e-scooters in public spaces. The possibility of sharing data between the

[84] Alonso & De la Vega, 2021. Interview to Marta Alonso, General Director of Traffic Management and Surveillance and Marcos de la Vega, Deputy Director General Legal Regime and Authorizations. A.G. Environment and Mobility of the Madrid City Council.
[85] Turismo de la ciudad de Madrid, 2021

city and the operator beyond the current geolocation is seen as very interesting by the City Council, complying with the GDPR, and protecting industrial property. Clearly, the ideal situation would be to have regulations at the state level to avoid differences between municipalities, but in practice each municipality dictates the regulations individually and that makes it difficult to integrate services between municipalities. The city must implement the changes little by little and in the future, the ideal would be the integration of the service between the different methods of public transport through the collaboration of public and private companies[86]. Smart regulation and willing responsible regulators are key to meet the needs of the city.

3.2.2. Málaga

Table 6. Málaga Data

MÁLAGA, SPAIN	2021
Population City of Málaga	577,405 inhabitants
Density	1,428,76 inhab./ km^2
Extension	398.25 km^2
Number of districts	11
Tender / Authorization	Authorization
Number of operators	8 authorized (not all of them have deployed)
Number of shared e-scooters	2,400 e-scooters (300 per operator)
Number of dedicated parking spaces	0

Source: Prepared by the authors based on Wikipedia.

In pre-pandemic times, up to 18 sharing e-scooter companies were operating with about 2,000 e-scooters with the complexity that is associated to such a number of different operators. Today, the city of Málaga is working with an authorization scheme with eight authorized companies. Only Dott, Link, Voi, Bolt and Bird are currently operating with 300 e-scooters per company. After several years of procedures and modifications, Malaga approved its Mobility Ordinance applicable to e-scooters and bikes in January 2021. The biggest change lies in the explicit prohibition of driving on sidewalks and pedestrian areas with these vehicles. The fines for not complying with this regulation extend up to €500. The ordinance also limits the speed for these vehicles to 30 km./h. in lanes and bike lanes, and the minimum age of drivers to 16 years.

There are currently 29 parking spots in the city[87] where e-scooters must be parked via technological features. The City Council asks the companies for a civil liability insurance of €1.5 million and the technical identification of vehicles is mandatory. When an e-scooter is not parked correctly, the municipal crane picks it up, takes it to the deposit, and then the operator collects all the scooters at the municipal facility without a penalty fee. In this case, operators are not forced to take responsibility for taking away the badly parked e-scooters[88].

The future vision of the City Council is to run a pilot test by launching a demand concession of public space for a maximum of two operators or a Temporary Company Union that could ideally provide the service of both shared bicycles and e-scooters to have a single interlocutor. The operator would ideally take care of the installation of the parking points in the street and of the management of the fleet vehicles. The goal of the City Council is to reach about 125 parking points and minimize the cost for the City Council[89].

[86] Alonso & De la Vega, 2021.
[87] Málaga City Council, 2022.
[88] Hernandez Mendez, 2021.
[89] Hernandez Mendez, 2021. Interview with María Trinidad Hernández Méndez, General Manager of Mobility in the Málaga City Council.

4. Lessons learned

It is important that the state regulations, the local regulations of each City Council and the General Directorate of Traffic are aligned and manage these services at the circulation and parking level with different regulations and dissuasive measures. Unfortunately, although the DGT created a general regulation for the circulation of Personal Mobility Vehicles, each municipality has the power to regulate the use of these vehicles based on their needs, making the situation completely different in each place.

- Meetings between management and operators are important to identify problems, face common challenges, share knowledge, lay the foundations for the service and discuss common solutions.
- Solid and clear foundations that take all stakeholders into account are the key for helping operators survive and guaranteeing an optimal and safe service for citizens.
- It is important to adapt supply, distribution and concentration to the real demand for mobility.
- A limited number of operators is positive for the user, since an offering that is too fragmented forces multiple applications to be installed to access multiple operators.
- Parking continues to be the key issue at the level of protection of urban space for shared scooters. Most of the offenses committed have to do with incorrect parking or in prohibited areas. In the case of Madrid, the Environment and Mobility area has reported more than 100,000 scooters for these offenses (representing more than 80% of the total complaints generated by bicycles, motorcycles, and scooters)[90].
- One of the most important challenges is to achieve a decrease in the accident rate and the number of violations in personal mobility vehicles (PMV), which has increased.
- Communication and training help make drivers aware of compliance with regulations such as not skipping traffic lights when traveling on the bike lane, respecting the direction of the roads and not circulating on sidewalks or areas exclusively for pedestrian traffic.
- The involvement of the police and urban parking enforcement in the monitoring of these infractions plays a key role in their compliance.
- The implementation of technological solutions that help to avoid violations and human errors when driving with PMVs will help reduce the accident rate and the incorrect use of these vehicles.

[90] Mcloughlin, 2021.

5. Barcelona

Table 7. Barcelona Data

BARCELONA, SPAIN	2020
Population City of Barcelona	1.664.182 inhabitants
Density	16.428,25 inhab./ km^2
Extension	101,35 km^2
Number of districts	10
Tender / Authorization	Not available
Number of operators	0
Number of shared e-scooters	0
Number of dedicated parking spaces	0

Source: Prepared by the authors based on Wikipedia.

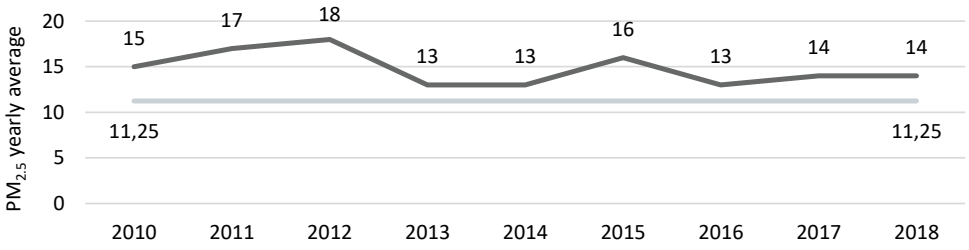
The Barcelona Metropolitan Area

The metropolitan territory of Barcelona occupies an area of 636 km^2 and consists of 36 municipalities with more than 3.2 million inhabitants. The Barcelona Metropolitan Area is considered the most important metropolitan agglomeration in the western Mediterranean, and it generates 50% of the Catalonia's GDP[91].

5.1. Climatic emergency in Barcelona

For the past two decades, pollution levels in the city of Barcelona have exceeded the limits recommended by the World Health Organization (WHO). Since 2010, the annual average levels of particles below 10µm (PM_{10}) have remained below the limits set by the European Union, but continued to exceed those set by the WHO, which are more restrictive[92]. Since 2010, the levels of particles below 2.5µm ($PM_{2.5}$) have also been exceeding the limits set by the WHO (see **Figure 6**). In 2021, the concentration of $PM_{2.5}$, the main pollutant in the air of Barcelona, is 16.5 µg/m^3, which is 1.6 times higher than the annual maximum value recommended by the WHO air quality guidelines, PM_{10} 17 µg/m^3, O3 58,5µg/m^3 and NO_2 12.5 µg/m^3, meaning a moderate contamination level[93].

Figure 6. Evolution of Yearly Average of $PM_{2.5}$ (µg/m^3) in Barcelona

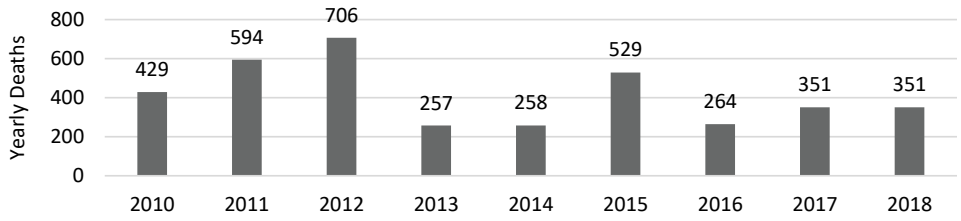


Source: Prepared by the authors based on Ajuntament de Barcelona (2019). The maximum recommended value by the WHO is 11.25.

[91] Àrea Metropolitana de Barcelona, 2020.
[92] Agència de Desenvolupament Urbà, 2020.
[93] IQAIR, 2021.

Traffic within the city limits has become the main cause of air pollution in Barcelona. Motor vehicles generate NO_2, which is the main pollutant that 48% of Barcelona's population is exposed to at a higher level than recommended by the WHO. The Barcelona Public Health Agency published a report on air quality evaluation stating that the number of deaths that could be attributed to air pollution is caused by ongoing exposure to pollutants generated by the city's traffic. According to the report, **air pollution was the cause of 351 premature deaths in Barcelona in 2018** (see **Figure 7**). Since 2010, approximately 3,749 people have died in Barcelona due to prolonged exposure to levels of $PM_{2.5}$ particles, whose levels have exceeded those recommended by the WHO. The main consequences of air pollution for the citizen's health are cardiovascular and respiratory problems, whose effects are more serious among the most vulnerable population groups, such as the elderly, pregnant women and children[94].

Figure 7. Evolution of Attributable Number of Deaths to Air Pollution in Barcelona



Source: Prepared by the authors based on information from the Ajuntament de Barcelona (2019).

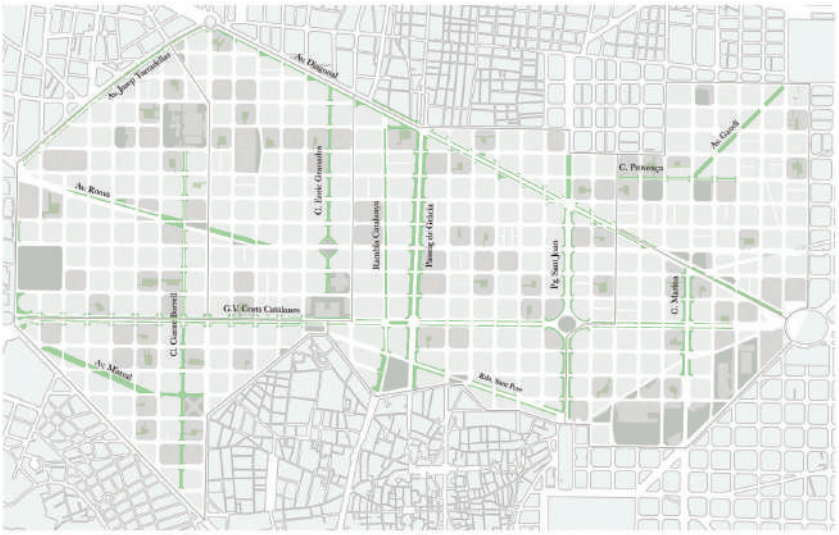
On January 1, 2020, the Barcelona City Council declared a climatic emergency in the city of Barcelona. More than 200 entities, experts and representatives of public administration collaborated to create an action plan and a package of urgent measures on mobility, urban planning, school environments, energy and waste management.

5.2. Towards a greener and healthier Barcelona

To promote healthy and sustainable mobility and improve the capacity and efficiency of the surface public transportation network, new bus lanes were created and speed limits of 30 km/h applied to seven additional streets where bicycles became a priority on the road. To complement the permanent low emission zone, vehicles with lower emission levels would be rewarded. To promote walking, outdoor activity, socialization and a healthier environment in the current pedestrian friendly areas (see **Figure 8**) and beyond, the city would continue to promote the pacification and greening of streets and the implementation of Superblocks added to the existing ones. To protect the health of children, the features of school environments have become a top priority for the city council, reducing transit and speed circulation near 27 schools. **Tactic urbanism** has permitted the rapid installation of the new so-called **"Ecoxamfrans"** adding public outdoor space to the entrances of school buildings. As a result, air quality has been improved in 85 schools[95].

[94] Ajuntament de Barcelona, 2019.
[95] Ajuntament de Barcelona, 2020.

Figure 8. Current Pedestrian-friendly Streets in the City of Barcelona



Source: Carlos Belmonte Bermejo Architect[96].

5.2.1. Pacification of the streets

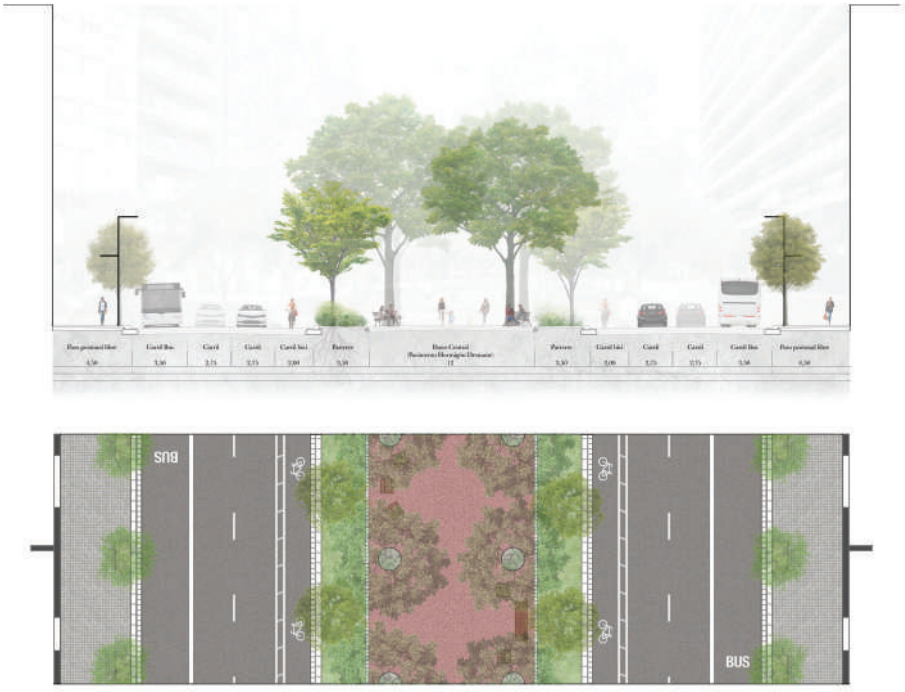
In 2021, the Barcelona City Council presented an ambitious model of **"New Green Axes"** (see **Figure 9**), which puts forward a new stage in the scale and territorial expansion of the Superblocks 2015-2020 program to act upon the Climate Emergency Declaration of early 2020. The consolidated and internationally recognized Superblocks program has already proven that a healthier, more secure, and inclusive Barcelona is possible. The concept was initially understood as a model with the vision and transforming capacity for the totality of the city through the sequential transformation of a set of currently car-centered streets (see **Figure 10**) in all the neighborhoods and districts of the city. The new Barcelona Street for the 21st century (see **Figure 11**) is designed to be citizen-centric, promote street life and activity, to innovate with a new environmental infrastructure, reactivate economy with proximity trade, with less air pollution and noise. The conceptualization of these streets was the result of a public contest promoted by the Barcelona City Council to materialize the foundation and features of these new streets based on the uses and configuration of space, the presence of green, accessibility, outdoor furniture, lighting and mobility[97].

Figure 9. Project Superblocks New Stage: Green Axes

Source: Carlos Belmonte Bermejo Architect[98].

[96] Belmonte Bermejo, 2021.
[97] Ajuntament de Barcelona, 2021.
[98] Belmonte Bermejo, 2021.

Figure 10. Example of a Car-centric Street of Barcelona. Floorplan and Section



Source: Current state of Josep Tarradellas Avenue, Barcelona. Drawing by Carlos Belmonte.

Figure 11. Foundation of the New Model of Streets for the 21st Century

Source: Ajuntament de Barcelona Presentació Superilla Barcelona 2021[99].

[99] Barcelona City Council.

5.2.2. Designing urban mobility of the future: Barcelona 2024

The Commission of Ecology, Urbanism, Infrastructure and Mobility approved on December 14, 2020, the **New Urban Mobility Plan for Barcelona 2024**. This UMP set as its main priority, the design of policies that contribute to building a more equitable, sustainable, secure, healthy and smart Barcelona. The plan has 60 lines of action and 340 measures, whose main goal is to reach an ambitious 81.5% of urban trips made on foot, by public transport or cycling. To achieve this goal, the main challenges are to guarantee the right to mobility, ensure the health and safety of citizens, contribute to local economies, and improve air quality while fighting climate change. After a period of allegations and public exposure the plan will be sent for approval to a plenary session of the Municipal Council.

Some relevant actions proposed:

For pedestrians: To remove motorcycles, bike lanes and obstacles from the sidewalks, add 32 kilometers of pedestrian streets, improve surveillance and control of compliance sidewalks, make public space more accessible to users with disabilities and reduce traffic near schools mainly in the entrance and exit times.

For bicycles and personal mobility vehicles: The plan is to increase the current bike lane network by 40%; include a lane with maximum speed of 30km/h. in streets with three or more circulation lanes to make it compatible with cycling; study the extension of the number of electric bicycles of the public sharing service "Bicing," according to demand; and develop a strategic plan for safe bicycle parking within the city.

For private motorized vehicles: To implement a 30km/h maximum speed limit throughout the city except certain connectivity streets; to promote the use of sustainable and silent vehicles, preferably electric while increasing the charging network; and develop a parking network with service to a more a diversified mobility mix: bicycles, motorcycles, urban distribution of goods, electric vehicle and shared vehicles.

For new technologies: Extending sharing vehicle services – cars, motorcycles, bicycles, and shared e-scooters – in the metropolitan area is a strategic aim[100].

5.2.3. Initiatives from the mobility governance entities of Barcelona

AMB: The metropolitan public administration

The Metropolitan Area of Barcelona, AMB, became the metropolitan public administration on July 27, 2010, when the Parliament of Catalonia unanimously approved the 31/2010 Law to rationalize and simplify metropolitan governance through the creation of a single administration. The AMB develops the necessary territorial structuring actions for the articulation, connectivity, mobility, and functionality of the metropolitan territory in terms of public space and infrastructure. The metropolitan environment now has its own Urban Planning Commission, which will enable all urban issues of the 36 municipalities that comprise it to be analyzed according to unified planning. There is a desire for the metropolitan environment to become a smart city, where the use of new technologies guarantees more and better services for citizens from a social, economic, and environmental point of view. The mobility and transport services managed by the AMB cover 70% of the metropolitan mobility that occurs in collective means of transport. The AMB has approved its first **Metropolitan Urban Mobility Plan** for the period 2019-2024. It is the metropolitan strategic instrument that integrates all mobility and transport policies and measures to be developed during the next years. Regarding shared mobility, its Measure 88 accompanies the implementation of shared mobility services, establishes the actions and path to follow in this field.

[100] Ajuntament de Barcelona Mobilitat i Transports, 2021.

According the to the leadership of the Mobility, Transport and Sustainability area of the AMB, current challenges are to improve existing services and create new ones capable of building more sustainable mobility alternatives. Another goal is to promote intermodality for moving around the metropolis and provide citizens with the tools to change their mobility habits and improve their health. Some of the main priorities of the AMB are, primarily, the creation of the Public Metropolitan Bike service; the licensing of a Metropolitan Shared Motorcycle service; and lastly, the regulation of shared e-scooter services, to which Barcelona should be the deployment leader and set the guidelines for the rest of the metropolitan area to follow[101].

The Barcelona City Council

The City Council's Urban Mobility Plan 2024 has the main goal of achieving **81.52% of urban trips on foot, cycling or by public transport by 2024**. Some of the main objectives of the plan are to increase the share of travel in sustainable modes: on foot (+ 7.5%), by public transport (+ 15.7%) and by bicycle (+ 129.4%) and reduce those made by private vehicle (-25.6%); promote the right to universal mobility, increasing and improving the conditions of accessibility and road safety of spaces dedicated to pedestrians; expand and improve the cycling infrastructure and the conditions of road safety, parking, coexistence and intermodality of bicycles and personal mobility vehicles; act on the conditions of use of the private motor vehicle, encouraging its energy transition to clean fuels, regulating its parking, and promoting its efficient and shared use and turn mobility into a set of multimodal, secure, efficient, and sustainable mobility services at the service of the user using internet and data management[102].

Priorities for the Barcelona City Council are, in the first place, the protection of public space. The public space in Barcelona City is very limited and inappropriate use can cause conflict. The City Council wants to pacify the city and that sense shared mobility could potentially help to decrease the occupation of public space because these vehicles spend less time immobilized. Priority number two is to regulate shared bicycles and motorcycles on a metropolitan level and increase the network of bike lanes by 40%. Priority number three is the regulation of shared e-scooter services. In 2017, the regulation of e-scooter circulation was first implemented. Next steps in the process will be to first determine the bases of a potential tender, and then call for licenses. In the mid to long term, shared e-scooter services will evolve citywide and ideally will be connected to public transportation to boost intermodality[103].

The TMB, Barcelona Metropolitan Transport

Transports Metropolitans de Barcelona (TMB) is the commercial brand of the main public transport management company in the city of Barcelona and its metropolitan area. TMB is the common name of the companies "Ferrocarril Metropolità de Barcelona SA", and "Transports de Barcelona, SA", which manage the metro and urban bus network on behalf of the Metropolitan Area of Barcelona, among other companies managing the cable car and other transport services[104].

In September 2021, the TMB published highlights of its **Strategic Plan 2025**, which included a new service for shared electric e-scooters to expand the provision of transportation beyond bus and metro[105].

[101] Bigas Serrallonga & Conill Verges, 2021) Interview with Joan Maria Bigas Serrallonga, Director of the Mobility, Transport and Sustainability area of AMB, and Carles Conill Vergés, the Director of Sustainable Mobility Services of AMB.
[102] Barcelona City Council, 2021.
[103] Valdes, 2021. Interview with Manuel Valdés López (Deputy Manager of Mobility and Infrastructure in the Barcelona City Council).
[104] TMB, 2021.
[105] Premsa TMB, 2021.

5.3. Removing cars to create new sustainable trips

A study conducted in Munich showed that instead of lowering car use, the shared e-scooter service competed over public space with people using bicycles, walking or using the public transport network – the most environmentally friendly means of transport in any city[106]. A survey conducted in Vienna reported similar findings about the expectation of replacing the use of private cars with e-scooter trips, also noticing that e-scooter trips were replacing walking trips[107]. The conclusion in both of these cities was that shared e-scooter services were not creating new sustainable trips but were instead replacing them.

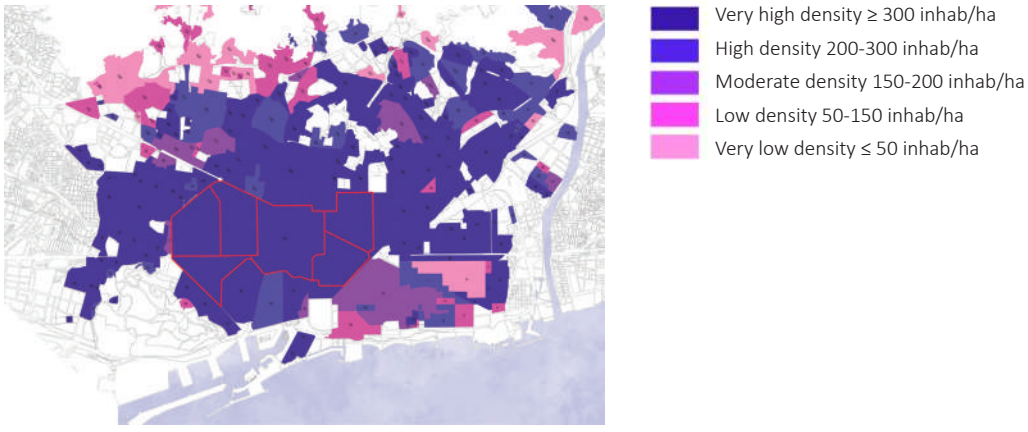
This was not the case in Barcelona. Due to the strong commitment of the City Council to remove cars from the streets and thereby creating a new need for mobility within the city limits, a shared e-scooter service would serve as a complement to the current means of transportation available in the city. It was determined that e-scooters would create new sustainable trips, substituting car trips, within the city and would not compete with sustainable modes of mobility such as walking, cycling or using the city's public transportation service.

5.4. Questions arising for Barcelona

In its vision of the mobility of the future, Barcelona needs to be the leader of any initiative. There is an increasing need to understand why people move instead of how people move in order to create more efficient intermodality networks. The current mobility paradigm is shifting from vehicle ownership mobility use as a service, paying per use not per asset. The final goal is to have **fewer vehicles** in the public space with **higher use intensity**, and therefore using less public space.

Some 80% of internal mobility in Barcelona is already sustainable (walking, public transportation, bike, PMV). Shared e-scooters could potentially boost intermodality, rather than serve as a tool for tourist leisure. However, the main concerns about their deployment remain: security, the use of public space, parking and the interaction with other users of the public space and other vehicles. As shared e-scooters services are private services operating in a public space, the City Council must regulate its activity. Moreover, Barcelona is a very compact city, with the highest population density in Europe (see **Figure 12**), therefore the service must work optimally from the beginning. Barcelona probably will not test the service through a pilot program as London has done. The city already has the expertise obtained from bike and motorbike sharing services and wants to offer a quality service to citizens that does not generate conflict or be rejected by citizens. Many questions arise such as: Should e-scooters be registered and have a license plate? Should there be speed limits? Should vehicles' features be determined? Should users have insurance and wear a helmet? How could externalities be minimized? Can the service be free-floating? When the time is right, the city will launch the service through a tender to offer a quality service to users and for operators in order to be profitable[108].

Figure 12. Population Density Map of Barcelona



Source: Carlos Belmonte Bermejo Architect[109].

[106] Gössling, 2020.
[107] Lee & Leth, 2020.
[108] Jiménez, 2021. Interview with Antonio Jesús Jiménez Rodríguez, Chief of Staff of the Mobility Department, Barcelona City Council.
[109] Belmonte Bermejo, 2021.

The “golden triangle” would mean that users receive quality service with a quality vehicle at an acceptable price with minimum externalities for the city (safety and parking). E-scooters need to be a solution, not a hindrance, and operators should be able to make money and offer good service and vehicles, pay acceptable salaries, avoid externalization and invest in product and service improvement. They must also be able to decide on the necessary number of e-scooters to be able to operate as profitable businesses[110].

What the current administration is thinking[111]

The administration is currently engaged in active listening with every stakeholder involved in shared mobility. Both the operating companies and the city council share the concern of avoiding improvisation. Projects need to mature; time must be taken to communicate properly to the stakeholders involved and each of them should be actively listened to.

The maxim of the Barcelona city council is quality. Therefore, the current task of the mobility management is to make sound decisions aimed at reducing any current disarrangement in the public space, with quality, order improvement, and long-term viability in mind. The city council’s strategy will involve making decisions in various areas of high priority and impact. The council is assessing the feasibility of vacant shared bike licenses and is also working on the viability of the shared metropolitan motorcycle licenses. Barcelona is also preparing a public tender for the installation of parking for scooters that could be used both for an eventual future public/shared service and for private use. Some locations have already been studied around the city and they are expected to act as multimodal hubs connecting with public transportation and other mobility alternatives. These would be conceptualized as very simple racks, without any other infrastructure or charging devices, in which several scooters could fit.

A work in progress for the Barcelona City Council is to prepare a public tender for the license to use the public space for the e-scooter business in Barcelona. The regulatory capacity of the city council is limited to regulating the use of public space, not its economic activity. Since public space is limited and meant for the common use of the citizens, it must be priced through competition regulation. The Barcelona City Council is showing leadership to control an efficient use of public space and is thoroughly studying the best practices of other cities and the potential and capabilities to offer this service in an excellent way. The City Council is aware that anything that has a direct impact on the streets and citizens, such as shared e-scooter services, needs to be taken very seriously to avoid discomfort among citizens. Risks must be taken, but they must be limited. Public tenders are filled with bureaucratic and legal procedures that extend the time needed for their launch, and the City Council is taking its time to think this matter through seriously and searching for the best option by openly approaching all the stakeholders involved. The viability of a shared car service is also being currently studied. Barcelona wants to remove cars from the streets, but to do so, citizens need as a quality alternative, public transportation that works with speed, capacity, frequency, good connection and intermodality. All these elements should be part of a 360-scope strategy.[112]

[110] Jiménez, 2021.
[111] Altisench & Serret, 2021. Interview with Oriol Altisench Barbeito, Assistant Mobility Manager Barcelona, and Elisabet Serret City Council.
[112] Altisench & Serret, 2021.

6. Recommendations for Barcelona

There is no universal solution for this issue as every city and metropolitan area is different, but everyone can learn from the failure and success of previous experiences. No one can be ready to solve every possible issue because most of the time they will arise as operations and citizens adapt to new situations. The goal must be to be prepared as soon possible: the sooner stakeholders join forces to design the service, the better the outcome. As seen when studying the experiences of both London and Paris, meetings involving all stakeholders are encouraged to identify and give visibility to common issues, and share a future vision, challenges, risks data, and knowledge to build a solid base for a successful service for everyone.

Public private governance for a sustainable mobility system

Barcelona needs a public-private instrument for planning and managing mobility. Currently, each municipality of the metropolitan area has its own mobility managers and decision-makers (City Councils, Metropolitan Area, Generalitat de Catalunya, ATM, TMB, AMB, the Ministry) without there being an instrument (as exists in other large metropolitan areas) that manages the entire system with an overall vision. In this sense, the optimal instrument is that of the Metropolitan Transport Authority, which should give entry to its governance not only to all administrations (and specifically also to the Government of Spain) but also to the private sector. This metropolitan instrument should integrate capacities on regulation, planning in infrastructure investment, public transport operation, and mobility management with private actors in employment-intensive areas such as industrial estates, economic zones and districts, the promotion of integrated service platforms within the framework of new mobility ecosystems.

Likewise, this metropolitan mobility management requires private participation through the large operators that have a key impact on the success of the system. Catalonia has a strong tradition of association and private participation and investment in issues of common interest that must be valued and fully involved to make the system sustainable and efficient. It is also important to consider the experience of large metropolitan transport operators which, such as TMB, unique companies that make up two of the large collective means of transport (metro and bus) and with a very high potential for innovation and service to the client and capability contribute to propose practical and useful solutions to metropolitan mobility. The governance proposal should be inspired by international experiences[113].

Regulation for innovative urban mobility

It is a fact that innovations in urban mobility directly impact the use of public space and urban life on social, environmental, and economic terms. In the case of urban mobility, innovations in shared mobility may advance at a pace led by private companies that is much faster than policymakers can manage. Even for innovations in urban mobility promoted by public authorities, existing regulation might not be suitable. In terms of the use of public space, public authorities should designate the location, dimensions and right density of specific parking areas to provide a fair service. Demand should also require public authorities' intervention to ensure a market that has a balanced supply and demand with the right fares and costs of the service for users and a healthy relationship with the urban environment.

Effective regulation rewards good practices and is not an impediment to entrepreneurial activity. On the contrary, the absence of this can generate negative externalities that impact public space, citizens and the economic activity of the area. The objective of regulation should be to help achieve a faster, cheaper, multimodal, and more efficient transport system that suits the needs of the users. An effective regulation system can help match supply to demand, promote energy transition and encourage multimodality through MaaS. Mobility innovations are in constant change, and they will continue to do so over the next few decades. The challenge for policymakers is to create strong legal and regulatory frameworks that can adapt to the changes and potential deficiencies of urban mobility innovations[114].

[113] Andrade, Díaz-Roig, & Hernández, 2021.
[114] Franca, Ricart, & Berrone, 2020.

7. Acknowledgements

This report has been sponsored by Dott, a micro-mobility European operator managing over 50,000 e-scooters in 38 top cities in Belgium, France, Germany, Italy, Poland, London, Norway, Finland and Spain. Environmental excellence is a priority in the company's development. The unique approach of the company is based on in-house operations since day one, since Dott operates 100% of its services through its own local full-time employees, rather than relying on the gig economy or local contractors. This brings additional safety, reliability for the city, and much better overall user experience. It also entails careful deployment in each city, launching in one city at a time and working together with local authorities. Ensuring all rollouts are tailored to the individual needs of each city. Dott focuses on sustainability and works to reduce its carbon footprint thanks to custom-designed, long-lasting vehicles, 3-year lifetime, with proper maintenance, extremely efficient operations: tracking and optimizing everything, repairing everything and recycling that which cannot be repaired. Sustainability also comes by using a fleet of e-vans and e-cargo bikes for operations and renewable energy for recharging scooters and the logistics fleet. With carbon offsetting, Dott achieved carbon neutrality in January 2019. In 2020, its carbon footprint was reduced by 56%, compared to the previous year.

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- Joan Maria Bigas Serrallonga, Director of Mobility, Transport, And Sustainability, AMB
- Carles Conill Vergés, Director of Sustainable Mobility Services, AMB
- Marta Alonso, General Directorate of Traffic Management and Surveillance Madrid City Council)
- Álvaro de la Vega Marcos, Deputy Director General Legal Regime and Authorizations, Environment and Mobility, City of Madrid.
- Trinidad Hernández Méndez, General Manager of Mobility, Málaga City Council

Exhibit 1

Key concepts summary of the first 2019 version of the "Charter of good conduct" for Paris

Compliance with the operative regulatory context	
Regulation relating to the parking and circulation of electric scooters.	
Paris City Hall	Bans the use of scooters on sidewalks and reserves the right to issue a ticket to users of scooters traveling on the sidewalks.
Paris City Hall	Provides specific parking solutions to ensure a dense network across the Parisian territory. Users must park FFES in the designated parking spaces and Paris reserves the right to issue a ticket to users of scooters obstructing pedestrian traffic.
Operators	Responsible of placing their scooters in locations specified and listed.
Operators	Put the means to ensure that users park the scooters in designated parking spaces after their ride.
Regulation relative to the quality of the electric scooters and rental conditions.	
Operators	Must offer reliable, secure, and quality equipment compliant with French and European standards.
Operators	Responsible for technical failures in their equipment resulting in accidents, damage or damage, with regard to the City of Paris or third parties, without possible recourse against the City of Paris.
Operators	Encourage users to wear helmets and drive safely.
Operators	Obtain a certificate that proves the user has the legal age needed to use the service and have a personal liability insurance.
Commitments by operators to set up a maintenance and regulation system	
Operators	Reporting, maintenance, and regulation systems to avoid over-concentration of degraded scooters on public roads.
Operators	Must intervene within a maximum of 12 hours from the report of a scooter that constitutes a danger or disrupts pedestrian flows.
Relationship with the city of Paris:	
Organization of exchanges	
Operators	Participate in regular meetings with the services of the city to share their feedback and assess the prospects for the evolution and development of their offer
Operators	Set up an organization to promote dialogue and to respond to possible emergencies.
Operators	Contribute, in conjunction with city services, to the identification of preferred parking spaces.
Information on the evolution of supply and demand	
Operators	Communicate to City of Paris (Department of Roads and Travel/Mobility Agency) new deployments (number of scooters and service area) 15 days in advance.
Paris City Hall	Keep this data confidential and to reserve its use for the analysis of free fleet phenomena.
Data relating to the activity of operators	
Operators	Make available to the city data on the deployment and use of the service to understand the flows and optimize the parking network.
Paris City Hall	Keep this data confidential and to reserve its use for the analysis of free fleet phenomena.

Registration in a united and sustainable approach	
Operators	Clean sharing vehicles that emit neither greenhouse gases nor polluting particles.
Operators	Reuse and recycle scooters, with a view to the circular economy.
Operators	Maintenance and control fleet with clean vehicles, with a concern for environmental exemplarity.
Operators	Gradual supply of green electricity.
Operators	Suppliers of the operators with European rules of reprocessing and recycling of batteries.
Operators	Social responsibility of operators towards employees and service providers, ensuring the operation of the service and in particular the collection, recharging and disposal of vehicles.

Source: Prepared by authors based on the Mairie de Paris. "Charte de bonne conduite relative à la location de trottinettes électriques en libre-service." Minio Browser. Last modified March 14, 2019. https://www.api-site.paris.fr/paris/public/2019%2F4%2FCharte%20trottinettes-VDEFmodif.pdf.

Exhibit 2

Summary of the Ordinance 10/2021, of September 13th, by which the Sustainable Mobility Ordinance of October 5, 2018 is modified

- Electric scooters are forbidden to circulate and park on the sidewalk, bus lanes, streets with more than one lane in each direction, and along the entrances and sections of the M-30 that do not have traffic lights.
- Their circulation is limited exclusively to the road within zones 30 and to bike lanes, which is why they are also prohibited from circulating on interurban roads, crossings, highways, highways, and urban tunnels.
- The maximum speed of movement is limited to 25 kilometers per hour. When circulating in the reserved lane of bicycle sidewalks, cycle paths and zones 20, a distance of at least 1 meter must be maintained with pedestrians and, if this safety section cannot be respected, you must get off the electric scooter and circulate on foot next to the PMV. In public parks, they can circulate only in areas where you can go by bicycle, but if the paths are shared with pedestrians, the speed is limited to 5 kilometers per hour.
- Users of PMVs must comply with the general regulations on alcohol and drugs.
- The minimum age allowed to circulate with these vehicles is 15 years old. Minors of this age may only do so on scooters suitable for their height and weight and circulate on authorized routes, in spaces closed to traffic and accompanied and under the responsibility of their guardians.
- The use of an approved helmet is recommended. It is only mandatory for those under 18 years of age or if driving in a multimodal lane at 25 kilometers per hour.
- All scooters must have an approved bell, braking systems, lights and reflective elements.
- Users cannot make use of the mobile phone or headphones connected to sound players or receivers.
- It is not possible to ride, in any case, two people on the same vehicle.

Source: Ayuntamiento de Madrid. "Ordenanza 10/2021, De 13 de septiembre, por la que se modifica la ordenanza de movilidad sostenible de 5 de octubre de 2018." Ciudadanía - Gestiones Y Trámites. Last modified September 21, 2021. https://sede.madrid.es/portal/site/tramites/menuitem.5dd4485239c96e10f7a72106a8a409a0/?vgnextoid=70e07707d711c710VgnVCM1000001d4a900aRCRD&vgnextchannel=e81965dd72ede410VgnVCM1000000b205a0aRCRD

Exhibit 3

Comparative table of the cities of Paris, London, Madrid, Málaga and Barcelona

	Paris	London	Madrid	Málaga	Barcelona
	2020	2020	2020	2021	2020
Population	2,273,305	8,961,989	3,334,730	577,405	1,664,182
Density	21,258 inhab./km^2	5,666 inhab./km^2	5,418.47 inhab./km^2	1,428.76 inhab./km^2	16,428.25 inhab./km^2
Extension	105.40 km^2	1,575 km^2	604.30 km^2	398.25 km^2	101.35 km^2
Number of districts	20	32	21	11	10
Tender / Authorization	Public contract 2020 – Duration 2 years	Public contract 2021 – 18-month trial	Authorization	Authorization	Not Available

Source: Prepared by the authors.

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