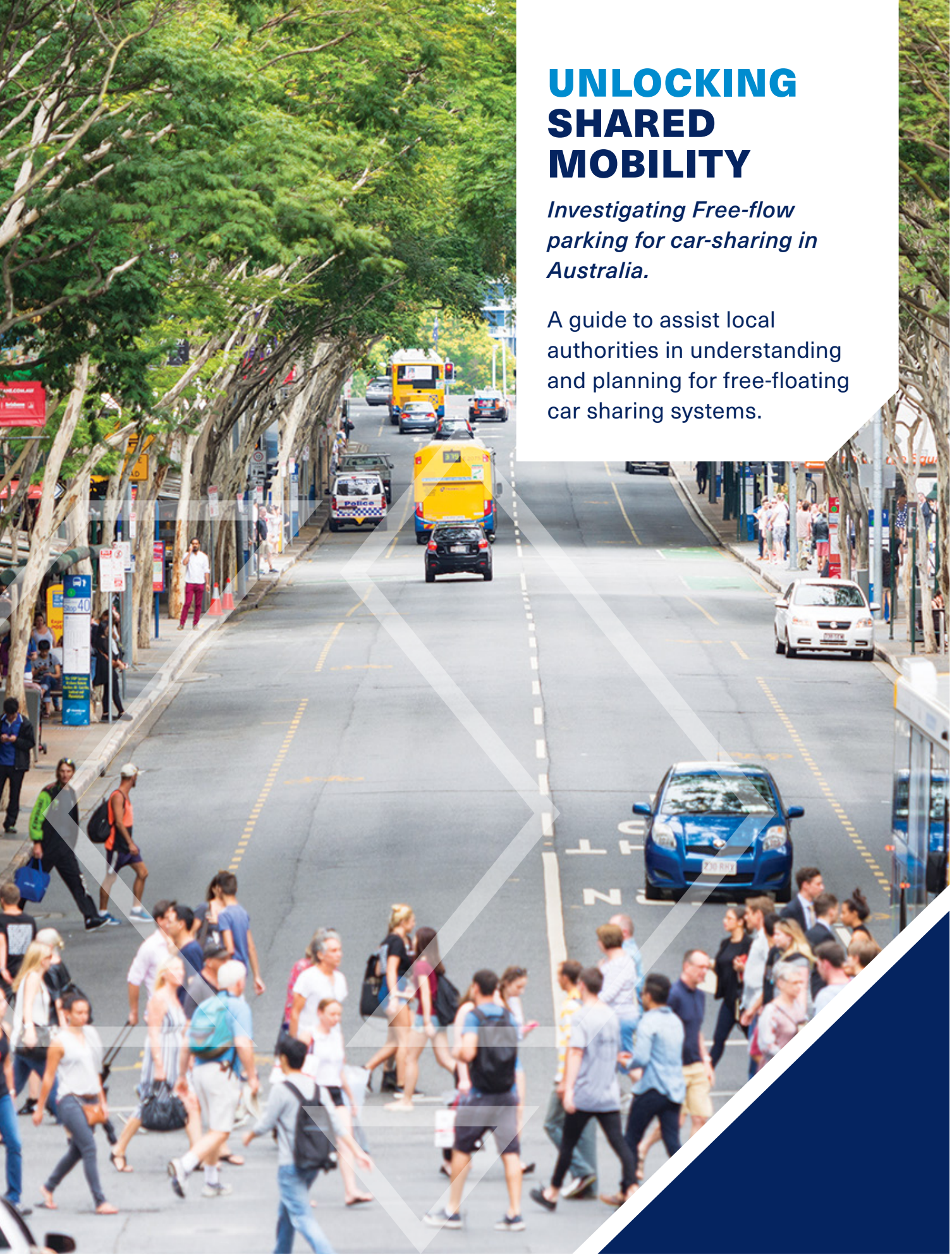

UNLOCKING SHARED MOBILITY

Investigating Free-flow parking for car-sharing in Australia.

A guide to assist local authorities in understanding and planning for free-floating car sharing systems.

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Intelligent Transport Systems

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Intelligent Transport Systems

NOTE: As this report is being published, the coronavirus pandemic continues to alter the deployment of many services and technologies mentioned within it. Although the pandemic's ultimate impact on transportation remains unclear, continued development and deployment of these transport innovations as well as the expansion of new vehicles will be impacted. While little can be projected with any real certainty the research suggests that the national and international pandemic impacts will only increase the need to consider interim interventions and activities to reduce impacts on our transport networks, public transport and communities more generally.

Contents

President's foreword

Dean Zabrieszach

In partnership with our members, ITS Australia works to design relevant and practical research projects to support a range of transport industry activities and goals. At ITS Australia, we build relationships, advocate for industry, and engage with government to inform and advise.

ITS Australia is a proud member of iMOVE Australia, the national centre for applied research and development in transport. As iMOVE participants, we have undertaken to contribute financially over a 10-year period and work to develop and participate in research projects that advance our industry and shape the future of transport in Australia.

To that end ITS Australia is very pleased to present this report Unlocking Shared Mobility: Investigating Free-Flow Parking for Car-share in Australia. This is a complex and challenging topic that impacts across a large range of stakeholders, including many of our members and the wider community.

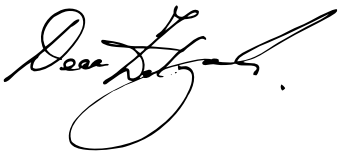
A great challenge for Australian cities—as it is for most of the cities around the world—is to achieve or improve the efficiency of their transport systems, exploring opportunities that technology and innovation can provide. Finding a suitable combination of modes for the different urban forms and needs means creating strategic networks, that keep public transport as the foundation, but which include other solutions including emerging new mobilities.

This is especially relevant in suburban or remote communities where the costs of implementing and maintaining fixed large-scale infrastructure can be significant and yet still fail to achieve the desired levels of accessibility and connection. Across Australia, there is increasingly intense competition for curbside space and parking. Roadside infrastructure management is a complex challenge in most jurisdictions. Working to better understand and improve current parking arrangements tackles a range of high priority issues for local and state governments, businesses, and our growing urban and regional centres.

To assist policymakers and LGAs assess if their urban environments can benefit from Free-Floating Car-Share, this report examines key issues facing FFCS implementation and provides evidence-based guidelines to government and industry. The guidelines are framed to enable each team to work with FFCS services in a way that best suits the communities in the areas where they operate.

The topic of this project is timely, placed in a fast-evolving field that increasingly requires understanding and critical analysis and which generates vast opportunities for engagement, experimentation and further projects.

ITS Australia can deliver this and other research projects only with the valued help of our partners, as well as our broader membership. I sincerely thank our partners on this project, iMOVE, RMIT University, IAG, Cubic Transportation Systems, and RAA.



Dean Zabrieszach
President, ITS Australia

About this report

This report was developed as a component of the project "Unlocking Shared Mobility – Investigating free-flow parking for car-sharing in Australia", made possible with funding from partners through the iMOVE CRC (Cooperative Research Centre) and supported by the Cooperative Research Centres program, an Australian Government initiative.

The iMOVE CRC is a consortium of 44 industry, government, and research partners engaged in a concerted 10-year effort to improve Australia's transport systems through collaborative R&D projects. It will help companies and Australia be more competitive, productive, and prosperous.

The main partners are: iMOVE Australia Limited, ITS Australia, RMIT (University), Insurance Australia Limited (IAG), Cubic Transportation Systems (Australia) Pty, Ltd ('Cubic' or 'CTSA'), and Royal Automobile Association of SA Inc.

This Project has worked in close collaboration with key stakeholders in academia, government, industry, and the community to better understand the current parking challenges and work towards a solution that enables the wider availability and usability of car-share services.

Date of publication: March 2021

Acknowledgements

ITS Australia and the project participants would like to thank the Project Committee for their time, insights and support through the development of this research and report.

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About this report

Project goals

Assess the potential, opportunities and challenges facing national and international cities regarding shared mobility:

- free-floating car sharing (FFCS)
- related parking issues

Provide an evidence base and guidance to government and industry that may enable them to work with car sharing services in a way that best suits the communities in the areas where they operate.

Identify key issues policy makers should consider to manage car sharing development in their cities and integrate it with public policy objectives and practices.

Methodology

- Desktop research - Review and analysis of existing national and international knowledge, with a special focus on FFCS.
- Stakeholder engagement inputs - Interviews, meetings and workshops conducted with relevant stakeholders from industry and government.

The initial workshops happened in 2019, with the City of Port Phillip, Waverley Council, and the Sunshine Coast; with the final workshop held online in 2020 with participants across Australia.

Report objectives

- Analyse national and international research and practice of car sharing, with a special focus on FFCS.
- Raise main issues related to FFCS facing cities around the world.
- Assess and build a foundational understanding of opportunities and challenges for the implementation of free-floating car sharing, contextualized to Australian urban areas, to inform and guide potential local developments of the mode.
- Present guidelines for future provision of policies and possible deployments of FFCS in Australia.
- Characterise and understand how FFCS has been deployed globally: a compendium of features, examples, and analyses of FFCS deployments and the market.
- Depict the profile of FFCS operations before the COVID-19 crisis.

Glossary

CS	Car sharing	AVs	Autonomous vehicles
FFCS	Free-floating car sharing	EV	Electric vehicle
SBCS	Station-based car sharing	EVCS	Electric vehicle car sharing
FFSB	Free-floating/station-based	MaaS	Mobility as a service
FFAB	Free-floating/area-based	OSFA	One-size-fits-all
P2P	Peer-to-peer car sharingCSO Car sharing operator	ICE	Internal Combustion Engine
TNCs	Transportation network companies	HEV	Hybrid Electric Vehicle

Introduction

Across Australia, there is increasingly intense competition for curbside space and parking. Roadside infrastructure management is a complex challenge in most jurisdictions so working to better understand and improve current parking arrangements will tackle a range of high priority issues for local and state governments, businesses, and our growing urban and regional centres.

The current station-based (SBCS) car-share services in Australia are proven to reduce the use of motor vehicles, and can also increase the use of public transport, cycling, and walking (Jain et al., 2018; Philip Boyle & Associates, 2016; Phillip Boyle & Associates, 2016). FFCS is a more recent and relatively flexible type of car sharing that allows members to use vehicles for short periods, picking them up and returning them anywhere within specified areas of a city or region. It has been introduced in a range of jurisdictions internationally as an additional option to station-based car-sharing.

FFCS removes the need for the shared vehicle to have a specific parking spot, most commonly allocated by a Local Government Authority (LGA), negotiated with the car-share provider. While a seemingly simple proposal, where users can collect a vehicle through their member app, pay for the trip costs, go to a destination of their choice, and park it where another member of the car-sharing program can share it, this can be a surprisingly complicated process to enable, and can cause public resistance.

The success of existing FFCS operations, mainly in Europe and North America, has been dependent on the parking and regulatory arrangements created for car sharing (allocation of space, access to special areas, permits, and technologies), that vary significantly from place to place, are tailored to local characteristics and managed by local public agencies.

To assist policymakers and LGAs assess if their urban environments can benefit from FFCS, this report examines key issues facing FFCS implementation and provides evidence-based guidelines to government and industry that may enable them to work with FFCS services in a way that best suits the communities in the areas where they operate.

The topic of this project is timely and placed in a fast-changing field, that increasingly requires understanding and critical analysis, which generates vast opportunities for research, experimentation and further projects. In addition, this project was developed in a particular period for the humanity, during the pandemic crisis of COVID-19 that hit the world in early 2020. The circumstances of dealing with this crisis have been impacting significantly all aspects of urban life. Urban mobility, an area already pervaded by constant changes and uncertainty, is especially facing fierce challenges during these strange times. Finally, the overall results of this situation still remain to be seen and understood.

NOTE: As this report is being published, the coronavirus pandemic continues to alter the deployment of many technologies mentioned within it. Although the pandemic's ultimate impact on transportation remains unclear, continued development and deployment of these technologies as well as the expansion of new vehicles will be impacted. While little can be projected with any real certainty, the research suggests that the national and international pandemic impacts will only increase the need to consider interventions as we have seen both nationally and internationally with the repurposing of public spaces and curbside real estate and increased government involvement in encouraging shared mobility.

Background – new mobilities in Australia

Cities across Australia have significantly different characteristics, ranging from few large and well-developed metropolitan centers, with suburban, sprawled and car dependent surroundings, to smaller (mostly in population) but sparse urban areas, similarly car dependent. Cars, roads and, especially, parking infrastructure are core parts of the Australian transport system and have been challenging sustainable urban planning practices. Processes to elaborate regulatory systems for transport in Australian cities would benefit from taking these differences into consideration and from creating tailored approaches and policies for each profile of city.

In fact, a more progressive approach to manage the Australian "system of automobility" (Urry, 2004) seems to be emerging in some cities. The content of current reviews in transport strategies and parking management schemes, followed by their challenging implementation (when accepted by the local community), suggest this shift on the way to deal with urban space. However, Australian cities still face challenges in regard to public understanding and acceptance of the measures.

Cities, like Melbourne and Sydney, have broad public transport networks which are currently being expanded and improved with the design and delivery of major infrastructure and digital projects. However, private car dependence and dominance are still among the main challenges that face Australian cities in their attempts to become more environmentally sustainable, especially the largest centers that are under pressure by the expected rapid increase in urban population.

Shared mobility modes have been implemented in Australian cities during the past years and keep evolving. These modes feature different stages of development across the country and are represented by car sharing, ride hailing and micromobility (docked and dockless bike sharing and scooter systems) schemes. Discontinued endeavors, in particular the dockless bike sharing ones, can teach valuable lessons about how some of these modes can behave in Australian contexts and about the issues related to new mobilities that cities will likely need to deal with in future attempts and/or deployments. Mobility as a service (MaaS) has also been incorporated into the agenda of discussion and implementations of transport initiatives in Australia. Many governments, across all levels, have been exploring the possibilities and opportunities that these new technologies and environments can offer.

Amid the emergence of new mobilities and in an increasingly uncertain future, a great challenge for Australian cities, as it is for most of the cities around the world, is to expand or improve the efficiency of their transport systems, exploring opportunities that technology and innovation can provide.

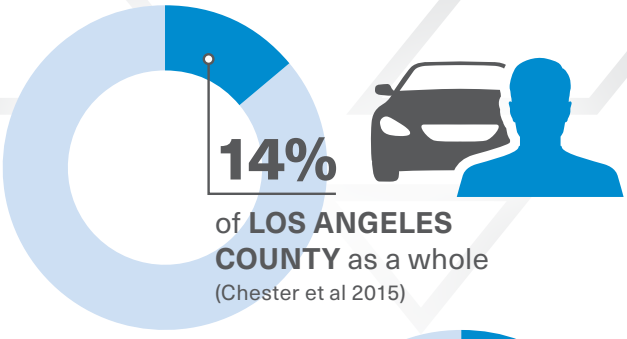
Finding a suitable combination of modes for the different urban forms and needs means creating strategic networks, that keep public transport as the foundation, but wisely consider all other potential solutions available. Especially where the costs of implementing and maintaining fixed large-scale infrastructure cannot meet the needs for accessibility and connection faced by suburban or remote communities.

The role of car parking and parking policy in cities and transport

Car parking is a significant use of urban land, comprising both public road space (or kerbside / curbside) and various types of private off-street space. Car parking supports car ownership and use for private vehicles – it is essential to car-based cities, and cities have been built or re-built around storage for cars. Car parking is essential to car-based travel and to car-based cities, with private cars stationary around 95 per cent of the time (Barter, 2019). Car parking occupies as much as half the ground space of some downtown North American cities (Ben-Joseph 2012; Shoup, 2005, p 131); and for example, 14% of Los Angeles County as a whole (Chester et al 2015); or 12% of floorspace in the local government area of Melbourne (Taylor 2018). Ample free parking is associated with higher car ownership and car use (Haman et al 2018; Shoup et al 2018). Throughout the 20th century the management of street space was reconfigured largely around parking for privately owned vehicles. Marsden et al (2020) surmise that new types of mobility, including car sharing, are shifting and intensifying the demands for street and parking space, but that public streets remain "a highly contested space which the state finds hard to govern effectively".

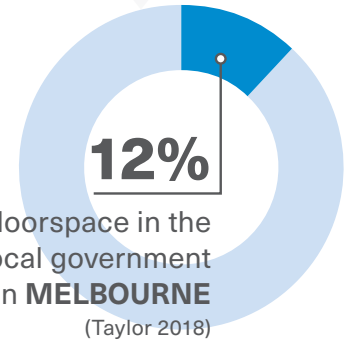
The availability and price of parking influences private car ownership and use with the provision of ample free car parking has a significant role in supporting and subsidising car ownership and car use. Public policy is closely involved in the provision and management of car parking for private vehicles. Governments typically require the provision of off-street private parking; as well as managing the use of public road space, including allocation for car parking space and the conditions placed on it. The availability and price of car parking is a key part of automobility and of supporting private car use and ownership. Just as private car ownership depends on car parking and parking policy, emerging mobilities, including car sharing, make claims on street space and are supported or constrained by car parking (Marsden et al 2020; Dowling et al 2018).

Car parking occupies



14%

of **LOS ANGELES COUNTY** as a whole
(Chester et al 2015)



12%

of floorspace in the local government area in **MELBOURNE**
(Taylor 2018)

Approaches to parking policies

Barter (2015) characterizes three basic approaches to parking policies: two mainstream ('conventional', and 'parking management'), plus 'market-based' approaches.

Conventional (supply-based, or 'predict and provide') parking policies use minimum off-street parking requirements and treat on-street parking as free infrastructure. On-street parking is usually free, and site-based minimum rates of off-street parking are required. Minimum off-street parking requirements emerged in response to rapidly rising car use in mid-20th century cities. They have been commonplace in most Australian cities since the 1950s. Conventional supply-based parking policies are increasingly criticised for subsidising car use and for over-supplying car parking at the expense of other transport modes and land uses. Critics argue that such approaches over-supply parking, subsidize car use at the expense of other land uses and transport modes, disguise the real demand for and costs of parking space, impact housing markets, and are an imperfect means of managing on-street parking (Manville 2017; McCahill & Garrick 2010; McDonnell et al 2011; Shoup 2005; Pierce and Shoup 2013; Shoup et al 2018).

By contrast, **parking management policies** use precinct-based, rather than site-based, parking strategies. They seek to manage traffic and land-use impacts and to balance competing parking demands, using tools such as timing and pricing (Litman 2018). Some parking management policies explicitly limit or reduce the amount of car parking (Kodranksy & Mermann 2010).

Market-based parking policy approaches are comparatively rare but include Japanese cities with little or no public on-street parking, combined with extensive private off-street parking based on willingness to pay (Barter 2011). With his claims for dynamic parking (Shoup 1998; Pierce & Shoup 2013), Shoup argues that local authorities should set the 'right price' for public (curb) parking, based on occupancy targets by time and location, and on driver willingness to pay. This allows minimum off-street requirements to be reduced: off-street and on-street parking are integrated to minimise both under-priced and overpriced parking. The profits from demand-based pricing, in Shoup's model, should be returned to visible local improvements via parking improvement districts.

Some arguments for alternatives to conventional parking are concerned with increasing the efficiency and availability of parking. Others are concerned with reducing subsidies to car ownership and use; or with reclaiming public space for purposes other than car parking (such as pedestrian space – e.g., Park(ing) Day). Car parking is often intensely politicized and asserted as a right rather than as a market good (Taylor 2014; 2018; Marusek 2011). This is particularly true where residential parking is concerned (Taylor 2014, 2018; Kent & Dowling 2016; Guo 2013b; Molenda and Sieg 2013; Van Ommeren 2011, 2014). In some contexts, residential on-street parking is completely free and unrestricted. In others, residential permits are used to manage non-resident parking by privileging existing residents over others (Marsden 2006; Van Ommeran et al 2014; Molenda & Sieg 2013).

Alternative approaches to parking policy take the position that public parking space is not a right as it does not meet the criteria for a public good and should be monetized; or that public parking space should be re-imagined as alternative forms of public space. In recent decades, arguments for parking policy change have typically called for reducing or removing requirements for off-street parking; and for some version of street space reallocation or kerbside management for public parking space. Marsden et al (2020) argue for greater awareness of public streets (kerbsides) and the competing claims made for them; and call for clearer policies on how existing and emerging claims to public street space are managed in the public interest. Similarly, a report by the Centre for London (2020) urged governments to develop clear hierarchies and principles for how street space is allocated, including for car sharing.

Car sharing

Car sharing is a transport system that allows members to use a car when they need one. “The principle of carsharing is simple: individuals gain the benefits of a private automobile without the responsibilities and costs” (Shaheen and Cohen, 2013, p. 6), or “burdens” (Alessandrini et al., 2015, p. 147), of car ownership. Members of car sharing schemes also have access to diverse types of vehicles, which can be used for different types and lengths of trips (mostly shorter than regular car rental trips), depending on their needs.

Car sharing has proven to reduce car ownership and use in many cities where it operates, but results differ across different jurisdictions. In addition research has shown that car sharing users tend to use transit, walk and cycle more, “shifting from a car-oriented to a public transport-oriented lifestyle” (Becker et al., 2018, p. 60), which increases the benefits car sharing brings to cities (Shaheen and Cohen, 2013). It is important to reinforce that most of the studies were done considering users of SBCS. Also, it is acknowledged among researchers and practitioners that car sharing will only bring these benefits if it is integrated with the wider transport system, and used as a complementary mode, just for the trips when a car is needed (Enoch and Taylor, 2006; Glotz-Richter, 2016; Kent and Dowling, 2016; Paganelli, 2019, 2013; Shaheen et al., 2010).

Graphical representation - types of car sharing

Source: Paganelli (2013, p. 36)

SBCS
station-based
P2P

FFSB
free-floating
station-based

FFCS
free-floating
FFAB

Types of car sharing

The evolution of technologies has impacted significantly in the development of car sharing and, currently, the system has different types of operation, or business models. These types are described below, and the image illustrates their main concepts.

- **Station-based** vehicles have to be returned to the point of origin to end the trip or booking, also called “round-trip” or “back-to-base”, “stationary”, “A to A”, depending on the location and context. Peer-to-peer services also belong to this type of car sharing, as vehicles have to be returned to the owner’s home after use.
- **Free-floating/station-based** vehicles can be taken from and left at any station of the system (like docked bike sharing systems), also called “on demand/ station-based”, “one-way/station-based”, or “one-way/ stationary”, depending on the location and context.
- **Free-floating** vehicles can be taken from and left at any available parking spot in the city, as long as they are inside a GPS delimited service area, defined by each provider. This type is also called “free-flow”, “flexible”, “on-demand”, “point-to-point”, “A to B”, depending on the location and context.
- **Free-floating/area-based** vehicles belong to and can be taken from a delimited area of the system in the city and have to be returned to the same area to end the trip or booking.

Additionally, some companies offer hybrid services, or “combined” (Nehrke and Ziesak, 2020), in which their vehicles can be used either in a “station-based” or in a “free-floating” way by the registered users, but the conditions of these systems differ significantly from one location to the other.

The role of parking in and for car sharing

Just as private car ownership depends on car parking and parking policy, car sharing models similarly are supported or constrained by car parking (Dowling et al 2018). Kent & Dowling (2016) argue car sharing relies on car parking space, and that policy gatekeepers for parking "exert substantial influence over car sharing's success". Marsden et al (2020) characterise public street space as "a highly contested space which the state finds hard to govern effectively". They note multiple existing and emerging stakeholders in kerb space, including car share companies seeking exclusive or cheaper access to public parking space and the formalisation of car sharing through regulation.

Car sharing relies on the infrastructure of private car ownership and sharing works both for and against prevailing systems of automobility (Dowling et al 2018). The politics of (private vehicle) parking, and typical policy approaches to parking, have implications for car sharing and increasingly other forms of Mobility As A Service or emerging transport technologies. Marsden et al (2020) are concerned there is a level of ad-hoc pressure on how streets are managed in response to new forms of mobility. They highlight inequities and inconsistencies with the current situation, but also that there are risks with responding to pressures from new forms of mobility without clear principles. Carrese et al (2020) also highlight parking policy as critical to car sharing.

In a meta-analysis of taxonomies of car sharing by Remane et al (2016), parking infrastructure is a key aspect of the 'service platform' of car sharing. Car parking is critical to the geography of car sharing as well as to the attraction of car sharing for users. Key physical types of car parking for car sharing are dedicated 'stations'; or stations attached to other locations (airports, or train stations); or (common in Australia) share cars parked on-street; or off-street in public or private parking areas or developments; or at private homes (for peer to peer).

As would be expected parking policies of different types have differing implications for car sharing. Considering station-based and peer-to-peer car sharing (see table 1), broadly, conventional parking policies lend themselves more to peer-to-peer operations where there are few parking restrictions but also no special privileges to car share vehicles. Station-based car sharing relies on allocated car parking. This model occurs and is successful in areas of parking management policies. Dowling and Kent (2018 p. 470) note that car sharing works where other transport modes are available, especially for commuting to work; and that car sharing areas are characterised by density and land use mix that typically results in pressures on on-street parking space. Thus, "the streets where car sharing is likely to be successful are therefore also those where car parking is scarce, and the reservation of parking space specifically for car sharing vehicles makes it an attractive alternative".

Timing, meters and other exclusions used to manage comparatively scarce parking space in these areas mean there is value in exemptions to these rules (Marsden et al 2020); and in the corresponding greater likelihood of having parking space for a car sharing vehicle. Often the exemptions valued and sought for car sharing vehicles are similar to those afforded through residential parking permits. Ampudia-Renuncio et al (2018) note that planners "play a decisive role" in shared-mobility: car sharing services "depend on privileged access to street space (uncongested streets, free or cheap parking space) which can only be granted by the public sector". While allocated parking appeals to users, Kent & Dowling (2018) reported "cultural distrust and/or ignorance of a new system" as an issue with non-users of car sharing, who resent the allocated spaces for car sharing. Local car sharing policies for reserved spaces sometimes set targets for the proportion of public parking spaces to be reserved for car sharing (e.g. 3.5% in Sydney, 3% in Calgary in Canada).

Parking policy typologies

Parking policy typologies combine with car sharing typologies to facilitate or constrain different outcomes. Each typology combination has its own barriers and risks. Parking and regulatory arrangements vary from place to place and should be tailored to local characteristics.

In a high-demand, managed parking situation, exemptions given to car sharing vehicles (subject to certain conditions) are typically through reserved spaces. Shaheen (2010) found that in North America over 70 municipalities had specific polies to favour parking of car sharing vehicles, typically through reserved spaces.

Options for parking policy for car sharing:

- allocated (reserved) spaces on and off-street (pods, areas, stations, hubs, EV stations) in public or private spaces.
- off-street reserved spaces or 'stations' (including at transit stations).
- permits (exemptions from normal timing and pricing) of different types (digital, cost per period/vehicle), parking fees.
- allocated/designated areas (with differing timing and pricing).
- access to and/or free or discounted parking in designated areas (low emission/central zones).
- technology-based data collection and pricing.
- hierarchical permits (e.g. free disabled parking, favourable pricing for shared cars, deliveries); time-based pricing."

Table 1: Car parking policy typologies and station-based or peer-to-peer car sharing

	Conventional supply-based parking policies	Parking management policies	Market-based parking policies
Off-street parking policy for car sharing	Can be used to lower site-based-off-street requirements.	Can be used to reduce site-based parking provision, or to transition to parking maximums. Parking 'stations' can support 'precinct parking' / unbundling.	Allows more use of parking supply in an area Can be peer-to-peer or based on commercial rents.
On-street parking policy for car sharing	Limited: few parking controls means no special provisions for car sharing. Suits peer-to-peer (unrestricted use of street parking).	Timing, pricing exemptions – reserved street spaces or permits. High appeal for operators of docked parking spaces in dense areas For users: exemptions = 'rock star park'.	No on-street parking: car parking and car sharing is off-street.
Risks	Limited appeal or viability of car sharing to users or operators. Private cars are dominant/ required.	Resentment / negative social norms around reserved car share spaces. Unclear hierarchy of public good for allocation of space. Enforcement issues: others parking in reserved spaces.	May have limited appeal given the dominance of other transport modes. Higher costs reserve cars and car sharing for higher income groups in high demand areas.

Key findings 1 – free-floating car sharing (FFCS)

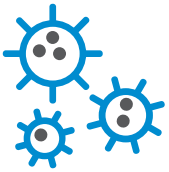
Source: Paganelli (2013, p. 36)

2008
First free-floating car sharing operation done in Ulm, Germany, as an experiment of Daimler.

2009–2018
Development and growth of FFCS operations globally, particularly in Europe and North America.

2019
Significant changes in the market: companies shutting down in many places globally.

2020



2021
?

Free-floating car sharing is a more recent and relatively flexible type of car sharing that allows members to use vehicles for short periods, picking them up and returning them within a GPS delimited area of a city and/or its surrounding region. Trips with FFCS can be one-way and bookings end (the payment stops) when the vehicle is parked in one of the authorized (concept that varies significantly from case to case) spaces within the service area.

The first free-floating car sharing operation happened in 2008, in Ulm, Germany, as an experiment of Daimler (Firnkorn and Müller, 2011; Remane et al., 2016). That was when the company Car2Go was created, although it does not operate there anymore. After that, Car2Go launched in Austin, USA (where it also has stopped operating), started spreading mostly around Europe and North America, and became the main global operator of this type of car sharing for some years (Kortum et al., 2016). In mid-2019, Car2Go has merged with DriveNow (another FFCS operator launched in 2011 by BMW, in Munich), to become a company called ShareNow, which, besides recent shutdowns in North America and some European cities, might still be the main or most significant global FFCS provider.

Like Daimler and BMW, many additional companies, from other automobile industry players, existing car sharing operators, and traditional car rentals to oil and energy industry players, technology providers, and startups or smaller organizations, followed the free-floating trend and developed operators for this type of service (FFCS) in diverse cities around the world. These operators apply different business and/or operational models (that vary from exclusively free-floating to hybrid services) in some cases, but with a similar approach to the way cars are accessed (free-floating) and used (one-way trips). Regarding FFCS operational models, perhaps the most challenging for companies and for local authorities are the hybrid systems in terms of defining strategic regulatory and management measures due to their complexity.

PRAGUE – RE.VOLT

BIEL – ENUU

ZURICH – ENUU

UNIV. USA – INNOVA DASH

FFCS operators tend to offer fleets with different characteristics globally. Vehicles vary significantly from micro two-seater vehicles, usually electric (offered by Enuu, in Switzerland; Re.volt, in Czech Republic; and Innova Dash, in the USA, for example – images below), compact city cars (i.e. Smart cars, Toyota Coms, Renault Zoe, Fiat 500, or Smarts, Citroen C-Zero, Nissan Micra, Hyundai i10, etc.), and sport hybrid vehicles (i.e. the ones offered by Evo, in Canada, and Gig Car Share, in the USA), to compact cars, sedans, station wagons, SUVs, pickups & cargo vans, with some hybrid and electric options among them, offered by most of the operators. However, the sizes and diversity of fleets also vary significantly among operators, as some offer one or few models of vehicles, while others offer a mix of possibilities in the same city or region. Some research is focused on fleets for FFCS, and studies also suggest optimal sizes for the system to work (Terrien et al., 2016). However, this number should be adapted, depending on the provider and, especially, the characteristics of the location.

Following current trends in transport, some of these CSOs are also offering a mix of services with micromobility options, i.e., motorcycles, scooters (electric or not), and/or bicycles. Examples of these operators are Aimo, in Sweden, Citybee, in Lithuania, Free2move, Playcar in Italy (Sardegna), GoTo, in Malta, Poppy, in Belgium, Re.volt, in Czech Republic, Vozilla, in Poland, Carusel, in Russia, among others (see Appendix 2 p. 65 of the full report).

Characteristics of FFCS systems

FFCS is used mostly for short and urban trips, and the purpose of these trips varies significantly, from planned to circumstantial ones, which becomes a challenge in trying to model or predict how this type of car sharing will be used. FFCS tends to be a convenient service to users (more than SBCS and P2P), because they get access to cars without the need to plan for their use in advance, like with SBCS. If they can drive and are willing to spend some time cruising for parking at the end of the trip, this mode can become more convenient than alternative transport. FFCS users can also make stops within one trip, which means that they can keep the car while solving errands in the middle of the way, and most of the operators offer free parking for these stops (see Appendices 1 and 2 of the full report).

The flexibility of FFCS also allows trips to be multimodal, for those who can use it, in which one of the legs is done with FFCS and the other(s) can be done with public transport options available in the city, or become an active trip, if the person decides to walk or cycle (where bike sharing schemes allow). However, due to the ad-hoc nature of FFCS trips, it is difficult to predict how they will be, as they will depend on a combination of factors that influence the user's decision, like most of the decisions for options in transport behaviors, and these conditions can change rapidly.

FFCS usual places – Research and studies developed on FFCS (Ceccato and Diana, 2018; Kortum, 2012; Kortum et al., 2016; Schiller et al., 2017; Tyndall, 2017) indicate that the characteristics of places and types of environments where FFCS will more likely work (and be more commercially viable) repeat among real deployments. In summary, FFCS tends to operate in:

- mid or high-density areas, like downtown areas, CBDs, historical centers, and their surroundings, as well as within and/or close to areas with higher density around major urban settlements,
- mid to high-income areas, characterized by significant economic development.
- areas with multimodal provision and relatively high mode share in public transport.

FFCS typical users – Studies that analysed characteristics of FFCS users (Ceccato and Diana 2018; Diana and Ceccato 2018; Müller et al., 2017; Schmöller et al., 2015) found that FFCS is more frequently used by:

- people with higher levels of education.
- people from higher income parts of the population
- relatively young people (between 20-40 years old), mostly males, and some millennials, who usually belong to small/low-size households.
- people with multimodal transport behaviors.

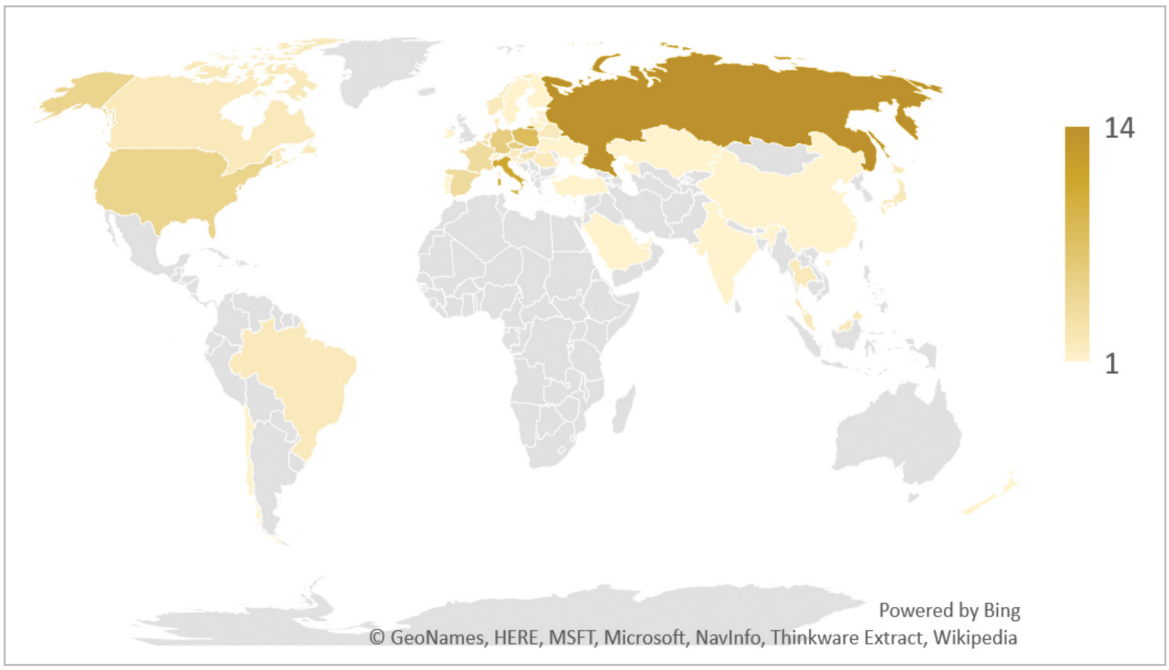
Where FFCS operates

This work has identified global FFCS providers considering data collected between January and April (2020). The aims of this survey were to depict the most comprehensive scene as possible for the moment and purpose of this project, and to understand how these FFCS systems were deployed. A list of these providers and the method applied to create this content (mainly desktop research) are provided in Appendix 1 of the full report. Due to the challenging times in which this work was developed, and the fast-moving characteristic of this field, with companies constantly entering and leaving the FFCS market, some of these providers may not be active anymore.

The map shows countries where the identified FFCS providers operate, and the intensity of the colors represent the quantity of operators found in each country during this data collection - darker colors mean more operators identified.

Countries with FFCS operations

Source: desktop research elaborated for this work (Jan-Apr/2020) – appendices of full report



Impacts of FFCS and its relationship with other transport modes

Car sharing in general tends to impact positively in mobility behaviours, reducing car ownership and use. However, when it comes to FFCS, key questions to consider are:

- Can impacts of station-based car sharing (SBCS) be replicated to free-floating (FFCS) services?
- What are the impacts of FFCS in car ownership and use, and in making people shift from the private cars to alternative transport?
- Does FFCS compete with sustainable modes of transport?

The answers to these questions are complex as the field of FFCS is permeated by controversies, assumptions and uncertainty. However, research and studies done in different cities have tried to give more clarity and accuracy to this terrain.

In summary, what studies have been able to answer so far is that:

- Car sharing impacts, specially FFCS ones, are location-related and influenced by the combined characteristics (conditions of the transport system, urban form, land use, etc.) of the place where it operates.
- Research results and impacts of SBCS are not 'transferable' to FFCS" (Becker et al., 2018, p. 52, 2017).
- Evidence in the public domain regarding the impacts of FFCS is embryonic (Ampudia-Renuncio et al 2018) and net environmental impacts of FFCS are still unexplored in research (Becker et al., 2018; Guirao et al., 2018).
- FFCS may help with the uptake of car sharing in general, influencing changes to more sustainable travel behaviours of users (Becker et. al. 2018, Martin and Shaheen, 2016).
- FFCS may compete with alternative transport and/or other types of car sharing for being a relatively convenient option in some cases (Firnkorn, 2012; Le Vine et al., 2014), particularly where the transport system is less efficient (Steiner et al., 2014) and the purpose of the trip favours the choice of FFCS.

Conclusions from some studies reviewed for this work also suggest that, due to the "complementarity of round-trip and one-way carsharing" (6-t, 2014) FFCS may generate more positive impacts in cities if combined services operate in the same area. For example, with the deployment of hybrid systems. A recent study developed by the German Carsharing Association – BCS (Nehrke and Ziesak, 2020) to evaluate car sharing (SBCS, FFCS and "combined", or hybrid) impacts from the user's perspective in Frankfurt, Cologne and Stuttgart, found that:

- A system needs SBCS services to replace private cars.
- FFCS can attract new users to the mode - as also concluded by (Steiner et al., 2014) - and can be used in parallel to car ownership.
- Combined systems seem to be the best options – "the best of both worlds".

Key findings 2 – issues to consider when implementing FFCS

Like other types of car sharing, FFCS needs urban space to operate. Defining a service area and how to allocate space for parking (access to special areas, permits, and technologies) before the FFCS operation starts in any city or region is crucial.

Allocation of space – service areas

Besides having some general principles in common, the final physical characteristics of service areas, and the way members can use vehicles within or in between these spaces, differ significantly from operator to operator, and from city to city. Service areas receive different names in existing operations of FFCS, for example: operation/operating, business, coverage, use, handover, or defined core areas; home, lease completion, travel or CSO, zones. Also, some FFCS operations allow users to travel in between cities (intercity trips), regions, service areas, campi, bases. The conditions for these operational modes depend on the providers and may imply in some extra payment.

Issues to consider when defining service areas for FFCS operations include:

- Commercially viable locations are the usual goal of providers when defining the area of operation.
- An equity approach from the regulators could ensure a wider coverage of the system.
- The process requires cooperation across borders and crucial negotiations with local authorities, in particular to solve operational and regulatory parking issues.

This work has identified similarities and differences in service areas of FFCS systems implemented globally. These characteristics were organized into 11 categories that are presented below. See full report for examples of each type of service area.

1. **Concentrated service areas:** Service areas with uniform shapes, that consider a part of the city as a whole for the FFCS operation.
2. **Fragmented service areas:** Service areas that consider one city or region but are divided into sections where trips can start and finish. These sections cover specific parts of the city, creating "islands" of operation. The shapes of these coverage "islands" vary significantly from one city to the other and, interestingly, vary substantially in comparison with the service areas of other local CSOs.
3. **FFSB service areas:** Service areas for the operation of FFSB systems (explained previously), which are usually the case in systems that offer shared electric vehicles, because they need to be connected to charging stations.
4. **Service areas with drop off zones:** Service areas that allow vehicles to be returned at "drop-off zones" located outside the main coverage area ("home area") but indicated in the usage maps. This option usually requires an extra payment, like what is offered by Sharenow in many of the cities where they operate.
5. **Service areas with parking "hot spots":** Service areas that include "hotspots"/hubs located inside or outside the main coverage areas, where vehicles can be parked upon space availability, during (normally for free) or at the end of the trip. The locations of these spots are usually informed to users via app.
6. **FFAB service areas:** Service areas for the operation of FFAB (free-floating area based) systems.
7. **Service areas with special sections:** Service areas divided by the CSOs in sections with special characteristics, where different conditions for the use of their vehicles apply. The main differences in the conditions of these sections are in terms booking tariffs, parking fees, and accessibility.

8. **Mixed service areas (FF + FFSB):** Service areas of systems that combine standard free-floating (FF) operations with station-based ones (FFSB – special parking spots or electric vehicles charging stations), within the same coverage area. These mixed zones are usually region-based, encompassing regional territories of major cities, and can also be divided into sections.
9. **Regional service areas integrated with transit:** Service areas that allow connections between different cities within the covered perimeter and relevant regional transport hubs (i.e. rail or bus stations and airports).
10. **Regional or extra-urban service areas:** Service areas with regional coverage that include different cities and important transport hubs (i.e. airports or rail stations) from the same country, and, in most of the cases, allow extra-urban or intercity one-way trips between these places. Intercity one-way trips are journeys in which vehicles can be taken from one city's coverage area and returned at another city's service area or station from the same operator. Conditions for these trips (physical and financial) vary from one operator to the other.
11. **Service areas of hybrid services (SBCS + FFCS):** Service areas that accommodate hybrid services (SBCS + FFCS) offered by the same operator, usually displayed on the websites and apps to guide their vehicles' utilization.

Spatial equity

(refer to the image on p. 41 of the final report)

Spatial equity is an issue. It is more likely that FFCS operations will cover areas with good public transport access and mixed land use, often higher income parts of a city or region.

Researchers tend to question the fact that FFCS operations do not usually cover regions that require better access to mobility, like low income, low density or suburban areas of cities, highlighting the need for local governments to explore services like FFCS to improve the transport provision in places with these characteristics (Kortum et al., 2016; Tyndall, 2017). Indeed, there is an opportunity for cities to explore FFCS services in disadvantaged or underserved areas, but it comes with the great challenge of enabling the establishment of financially sustainable systems for operators (with projects that incentivize them to provide services in these places), while also increasing the accessibility of the vulnerable areas.

Key findings 2

Allocation of space – parking

The role of allocation of road space and parking in FFCS operation, regulation and control is critical. Parking is an essential element of the system for all types of car sharing, particularly FFCS. It is the most important form of support from governments to car sharing (Dowling and Kent, 2015a; Shaheen et al., 2010) but also a significant "operational challenge" (Kortum 2012).

Allocation of space for FFCS parking can be **on-street** (in bays/pods, stations, designated areas, or mobility hubs), which requires negotiations and arrangements with local authorities, involving all the councils or cities affected by the boundaries of the service area; or **off-street**, which requires negotiations with private parking owners or managers. For on-street parking spaces, local governments need to decide how the available spaces will be allocated and used, how much they will cost (normally per vehicle), and how the companies will pay for them (permits and their lengths, conditions, payment cycles, etc.). The service seems to work better from operational and marketing points of view if parking spaces are provided on-street.

Knowing that there will be a guaranteed car on the spot when needed increases the reliability of car sharing and has a great impact on the decision to give up owning a car (Dowling and Kent, 2015a). Difficulty to offer this reliability is a challenge that FFCS services face in general. Station-based operations for one-way trips (FFSB) tend to increase the reliability of this type of car sharing because they provide dedicated spots to park the vehicles at the destination. However, **ensuring parking availability** at the final stations is a challenge faced by operators and users, similar to what docked bike sharing systems experience. This lack of available spaces may prevent the completion of the trips at desired destinations, compromising the convenience of both modes (Dowling and Kent, 2015a). A way some companies found to deal with parking availability issues is to offer **vehicle delivery and/or pick up (valet) services**, within or outside their coverage areas. Normally, these services require booking and extra payment, like the ones provided by ShareNow, GreenMobility, in Denmark, Share'n go, in Italy, Car sharing Bi-bi.car, in Russia, Awto, in Chile, Hayr Carshare, in India, and Yoyo, in Istanbul, for example. For more details on parking issues for FFCS, see Appendices 1 and 2 of the full report.

Parking policies for FFCS

The policies and risks associated with FFCS models have key differences. FFCS (as with other MaaS technologies) necessitates alternatives or arrangements, which should be negotiated with local authorities. In practice, FFCS parking is implemented in similar ways to residential parking permits, and often in combination with a central low emission zone or other policies favoring electric vehicles. Cecato & Diana (2018) characterize car sharing operators as private but as having privileged parking access either through dedicated spaces (stations), or through access to free parking areas or to low emission zones in European cities.

Typical alternatives and arrangements are summarized below and in Table 2 (see also Appendices 1 and 2 of the full report):

- Designated (reserved or valid) parking areas or spaces – per operator or class of vehicles.
- Authorized / permitted public parking spaces.
- Car sharing 'points', 'drop-off zones', 'hot spots', 'bases', or stations, particularly for EVCS – some allow reservation of spots.
- Special permits / exemptions for car share and similar vehicles (through mechanisms like residential parking permits) to park in public, permit only, metered or residential areas.
- (In theory) fully integrated timing and pricing systems.
- Mobility 'hubs' or 'stations', that can also be located in relevant transport hubs (i.e. public transport and rail stations or airports and require partnerships with the transport agencies), inside or outside the service area.
- Vehicle delivery / pick up and drop off – valet services.

Table 2: Parking policy typologies and parking issues particular to FFCS

	Conventional supply-based parking policies	Parking management policies	Market-based parking policies
Issues particular to FFCS	High possibility of clustering and commuting Difficult to address spatial and other equity issues: still likely to be unviable	Relies on exemptions and permits similar to residential permits: difficulty with justifying and with negotiating price Without special parking access, reduced appeal to users Higher possibility of illegal parking issues Possible increase in car use and congestion Requires defined service areas Competition with residential or turnover parking Greater demand for consistent data on parking controls and use	Difficult to address spatial and other equity issues: likely to be viable but expensive

Key findings 2

Features used in parking policies for FFCS

Typical features used in parking policies for FFCS (without commenting on their success) include:

- Residential parking permit style exemptions: these grant similar privileges to existing residential permits but usually apply over a wider area, and are charged a higher fee. In cities with a wide coverage of these 'digital permits' the permits are a major selling point of the schemes.
- These permits are used in central or inner urban neighbourhoods that have or have recently introduced hierarchical parking including residential parking permits.
- Free parking in designated low emission central zones; or free or discounted parking specifically for electric or low emission vehicles.
- Reliance on electric vehicle priorities: parking can be free at any electric charging station, which incentivises operators to start or convert fleets to electric. Examples include Madrid, Los Angles, Amsterdam, San Diego, Singapore, Turin, Wellington.
- Cities usually negotiate annual per-vehicle fees for operators to gain access to central zones or to parking permits. The amounts can be ad-hoc or general, and may reflect differences in the levels to which different operators use on-street space.
- Cities may also make requirements for accountability and reporting about travel behaviour and emissions impacts.
- Free access to paid parking zones, access to limited traffic zones.
- Access to areas normally restricted to residential parking or restricted by time. Some cities allow free access to metered spaces, others exclude metered spaces.
- All FFCS schemes are anchored to some kind of defined service area – some are specially designed; others reflect existing administration boundaries like municipalities or (in Europe) congestion and low emission zones. Can be a composite of districts; or a low emissions zone; or a customised area (sometimes through compromise). Some home zones exclude major downtown areas, others exclude high-pressure residential areas.
- Some cities use off-street stations/hubs as well, or allow access to docked station-based parking spaces. Others specifically exclude parking in private spaces or on docked spaces.
- Cities where emissions and other policies specifically support and enable electric vehicle infrastructure are sometimes used to incentivise FFCS operators.
- Some cities have differential parking fees for certain areas (e.g. Frankfurt), but this is uncommon. Differential parking prices are more the territory of proposals for future mobility parking models. Ciari et al (2015) model the potential of using differential parking pricing for managing demand pressures and clustering issues with FFCS.
- LeVine & Polak (2017) find that the greater impact on car ownership and use from FFCS would come from targeting moderate income households (Los Angeles does have policies focused on moderate income groups).
- It is common to use similar permits as to residential permits: termed 'digital permits', but really they are just exemptions tied to vehicle registration. The 'digital permits' typically have the same privileges and exemptions as to residential parking permits – permitting parking in areas with time limits, or marked for residential permits only. They extend over larger areas.
- The digital permits for car sharing are priced higher than residential permits (which are often free). For example, Washington D.C. negotiates for 'zone 9' permits, between $300-$3,000 per car per year depending on the operator.

For more information, see Appendices 1 and 2 of the full report.

Issues to consider when defining parking and regulatory arrangements for FFCS include:

Mediation between the demands of residential parking (and politics) and car sharing

Attempts to mediate between residential parking demands (and politics) and car sharing are thorny and can be intractable. A Vancouver report (Vancity 2018, p. 3) suggested that restrictive parking regulations forced BMW's DriveNow service out of San Francisco, and Toronto's "mediocre" car-sharing scene reflected drawn-out battles over parking rights. FFCS as with other parking rights afforded to car sharing pushes against norms and values around private car parking, reflected in conflict with residential parking and residential permits. Or affordance of similar privileges as to residential parking permits which are themselves problematic rights to public space. Ostemeijer et al (2019) argue that, given residential parking is usually free or very low priced, that residential on-street parking policy tends to subsidise or increase car ownership. Ostemiejer et al (2019) connect this observed effect of street parking pricing to the possible implications for autonomous vehicles.

Parking fines and illegal parking

Parking fines and illegal parking can be an issue – parking fines still accumulate, as the onus is now on the user to park the car legally. Some MaaS modes and delivery vehicles are key issues in illegal / improper parking – Brown et al (2020) find that ride-hail and food delivery drivers disproportionately park illegally. These are some of the other pressures to formalise road space reallocation.

Parking is both the incentive and the potential barrier to FFCS: there is a need to **balance fair access to parking** with the appeal of the 'golden ticket' type of exemption for FFCS. In Berlin, while any public parking spot may be used, there are no special rights to it and the availability of parking on-street in many Berlin neighbourhoods is unlikely and in some, "the possibilities of curb parking do not exist" (Muller et al 2017). In most cities with FFCS some more explicit privileges of access to parking is involved. In Berlin enforcement and illegal parking issues are prevalent with free flow car share vehicles. Even with privileges, in Vancouver finding a free-floating vehicle, especially at peak times in certain neighborhoods, can be "impossible". One response is to provide more vehicles at transportation hubs.

However, parking is "a deal-maker but also a deal-breaker": the possibility of easier free parking in a constrained city is an attractor, but where this is not attained the value of the car share use is undermined. Membership may be impacted as well as city goals, or parking enforcement. Dowling and Kent (2018) report users who initially accessed a car share without an allocated space ("it was just generally in a certain vicinity") and finding this more difficult. Trips ending while illegally parked – in front of fire hydrants, in other car company's spots, in no parking zones. Illegal parking was not a huge number in proportion to the number of trips but are still an issue. If FFCS is not given privileged access, then enforcement is a more likely issue (as in Berlin). However other kinds of emerging mobility are more problematic for illegal parking (Brown et al 2020).

Key findings 2

Hierarchy of road space allocation and curb space management

Ampudia-Renuncio et al (2018) argue that "the positive impacts of FFCS on public transportation are not sufficiently clear, and policymakers' role in ensuring privileged access by FFCS to on-street parking is a key issue for their future development". Others emphasize the need to explain to the public why car-sharing should be granted privileged parking access, and the value gained by allocating public parking space. While some FFCS agreements are ad-hoc and some are more general, policy makers still need to make active policy decisions. However, "the challenge is that the evidence in the public domain regarding the impacts of FFCS is embryonic, rendering it difficult to make informed policy decisions".

A clear hierarchy of road space allocation is needed to support car sharing including FFCS – in the absence of an articulated public good, the privileging or sale of public parking space risks being ad-hoc or privatised response to demands for codification (as argued by Marsden et al 2020). Parking is a critical and dominant function of public space, supporting driving. Marsden et al (2020) characterise two broad situations – one of unfettered chaos, and one with cars given priority. They list a multitude of curbside stakeholders in the exiting situation – with car share companies whose use comprises "exclusive access for pick up and drop off", with a goal of "cheap parking", to which "lobbying and some formal status in planning regulation" is pointed.

Cooperation and integration across borders

Cooperation and integration across borders can be a challenge for FFCS where there are multiple municipalities in a metropolitan area.

LeVine & Polak (2019) noted that, in London, "coordinating 32 separate authorities across different boroughs proved to be more difficult than anticipated". London is as example of inconsistent policies as a barrier to car sharing and particularly to FFCS. While the Centre for London (2020) urges London boroughs to develop hierarchies of street space including for car sharing; and to support car sharing as part of overall street and transport strategies ("kerbside strategies") that move away from privileging private vehicles; London's boroughs do not have consistent car share policies at this stage. Proposals are to develop a "fair price" for on-street parking for car sharing as a city-wide approach "to support harmonisation across boroughs". The lack of consistent parking policies and permit privileges across Boroughs has been a deterrent in London and is cited by some operators as a reason for exiting London. Drive Now and Blue City both citied "high costs of operation and the different circumstances in the single boroughs". Schiller et al (2017) surmised that FFCS stopped operations because they were "not able to secure parking permits".

Relocation and clustering of vehicles

On a theoretical level, a key issue identified with FFCS is relocation and clustering, and the asymmetry of demand for where cars are collected and dropped. Illgen and Hock (2019) note that the availability and special allocation of parking influences asymmetry – studies of demand however rarely take detailed account of differences in parking. Morency (2008 - cited in Kortum 2012) noted challenges with "variability in attractiveness" of vehicle locations – meaning difficulty with allocating and relocating vehicles. Vehicle relocation problems are identified by Bruglieri et al (2014); Millard-Ball (2019); Hao et al (2018). Increased car use is a risk identified by Ostemeijer et al (2019); Tian et al 2019); Wang et al (2018).

Tyndall (2017) finds in a study of 10 US cities with FFCS, that vehicles tend to be dropped off in clusters, disproportionately in areas with residents "who are educated, young, employed and white". Whereas car share is less likely to provide a basic level of service in other areas. Cars tend to cluster within their 'service areas'. LeVine & Polak (2019) find that the greater impact on car ownership and use from FFCS would come from targeting moderate income households (Los Angeles does have policies focused on moderate income groups). Social equity and spatial equity issues are considered by Zhang & Guhathakurta (2017), who also find that with the presence of parking fees (charged-parking), and shared autonomous vehicles, vehicles would likely move to areas adjacent to the downtown/CBD, which in Atlanta means low income neighbourhoods. Thus, they argue that parking pricing combined with other regulations should be used to reduce car travel (and potential social equity problems) resulting from autonomous vehicle parking.

Integration with other transport modes

A practical way to integrate car sharing with other modes of transport is to make vehicles available near or at public transport stops, stations or multimodal hubs.

"Mobility hubs" are examples of this integration, a concept that the city of Bremen, in Germany, put in practice decades ago with their "Mobilpunkts", and has been inspiring other cities since then (like Bergen, in Norway). This concept has been adjusted and applied by other cities around the world and incorporated into valuable guides for decision makers developed by organizations that work on the field (Bremen, n.d.; Shared-Use Mobility Center, 2018a; Taxistop, n.d.). Germany has been teaching good lessons about this topic, and a relevant example of this concept was developed by the city of Hamburg, the hubs called "Switchh".

These multimodal mobility hubs, or "Switchh points", were created by the city's transit agency (HVV – Hamburger Verkehrsverbund) and include public transport, car sharing and bike sharing. They are usually built around public transport stations for trains (U or S Bahn), trams, buses, depending on the case, and there are 72 of them spread around the city. Different modes of transport are also concentrated within these hubs: car sharing (SBCS and FFCS), bike sharing, parking facilities, and charging stations for electric vehicles (HVV, n.d.; Shared-Use Mobility Center, 2018b, p. 16). Customers can find real-time information about the modes available in the HVV app –(Shared-Use Mobility Center, 2018b, p. 16).

The image shows screenshots from the Switchh website with an image of the Berliner Tor station hub, a picture of another on-street hub, and the map of points located in the region. This example is relevant to this project because the hubs include both types of car sharing within the transport options, with spaces for FFCS vehicles. The hubs also represent ways to support and integrate FFCS with the city's transport infrastructure.

Switchh points in Hamburg, Germany
Source: Switchh (n.d.)

Key findings 2

Interaction of FFCS with other new mobility modes

It is important to consider how other shared mobility modes are used in the cities and the interactions they may have with FFCS. Conversely, managing these interactions, to ensure they will be beneficial for cities, challenges the already complex role of local governments. Varying from case to case, they can interact differently with each other. In comparison with taxis or ride-hailling, modes that are more flexible and allow a certain freedom (everyone can use them, non-drivers and disabled, as long as they can afford the trips), FFCS may not be so convenient, because members are required to drive and look for parking at the end of the trip.

However, in comparison with SBCS, one conclusion from research is that, besides the potential, and identified competition between both types (Becker et al., 2018), FFCS can also help to consolidate car sharing as a transport mode in cities. This role is explained by the fact that even if or when FFCS brings negative impacts in terms of car use, it can help "advertise" car sharing as a mode, perhaps encouraging people to consider other options for transport that are not their own cars.

For instance, results from Becker et al.'s (2018) study suggest that "a free-floating car-sharing scheme not only complements, but partially competes with existing station-based car-sharing schemes". However, "despite a slightly weaker impact than for station-based car-sharing", it can also "trigger a shift away from private vehicle ownership", and "it seems to complement a public-transportation oriented lifestyle" (Becker et al., 2018, p. 60).

Data digitalisation and sharing

It is widely recognized in literature and practice that data from different sources about how transport modes are used in a city are constantly needed, and that this information is strategic to enable informed and appropriate decisions in terms of planning, regulations, support and investments. This is especially the case for FFCS, as local planners need to understand how vehicles are being used in their cities. FFCS operators can provide valuable information to local governments on the characteristics of the trips made with their vehicles, like origin, destination, distance and duration, as well as on the profile of users (demographics) and their behavior or approach toward cars.

Moreover, acquiring and analyzing these data are crucial steps in the process of understanding the impacts FFCS generates in a city (Namazu et al., 2018; Schreier et al., 2015). However, getting access to strategic data can also be one of the most challenging parts of FFCS management, hindered by difficulties of dealing with sensitive information, about users (personal details) and providers (particularly those related to commercial issues and the usage of the vehicles), and their implications (Namazu et al., 2018; Schreier et al., 2015).

Data and technology limitations

Together with parking matters, data sharing is, usually, a controversial topic in negotiations related to FFCS. And, amid this complexity, cities tend to deal with issues of data in an ad-hoc or case by case basis.

Firnkorn and Muller (2015) proposed that the better model for FFCS is for "large car sharing-fleets parked in integrated vertical parking and charging facilities". To Firnkorn and Muller (2011) the advantages of car sharing are both reducing emissions through requirements for electric vehicles, and through a reduction in land consumption for parking. Cities generally lack the data and infrastructure for this model and rely on existing mechanisms instead.

Some research (e.g. Ciari et al 2015) proposes differential parking rates for FFCS, however this is relatively uncommon again largely due to a comparative lack of real-time or accurate parking data across cities: there is a lack of homogenous parking policy data in many cities. In the absence of these, FFCS schemes rely on other parking policies: low emissions zones, residential permits, electric vehicles parking. Where these parking situations are absent, FFCS can be limited. For example, London has a significant amount of private vehicles parked on-street, at low or little cost. The use of FFCS is limited where there is a lack of on-street parking management overall; or lack of policies supporting electric vehicles parking.

Experimental approach – the value of pilots and experiments

Research and literature widely acknowledge that there is no OSFA solution for FFCS implementation, which means that successful measures adopted in some places should not be transferred to other cities or regions without tailoring. The different ways how FFCS is implemented (types of services areas presented globally emphasize that. And, to reinforce previously mentioned issues, the impacts of an FFCS system depend significantly on the mix of characteristics of a city and on how members use the vehicles.

With respect to that, pilots and trials can be valuable tools for cities that need, or are willing to, enable and manage FFCS operations, provided there is a proper structure and team behind them to plan, implement, manage and analyze their results (Terrien et al., 2016). In fact, experimentation is recommended by different relevant actors, and "local governments should trial or promote car sharing based on the success of current schemes" (NRMA, 2017, p. 4).

The experimental and temporary approach of these initiatives gives a chance for cities to understand how car sharing behaves locally, as well as to measure and evaluate its local impacts, without the pressure of definitive implementations. In particular, it allows an understanding of what happens to car use and parking after the deployment of these pilots (Strömberg et al., 2016). Furthermore, results from Terrien et al.'s (2016, p. 30) analysis of different FFCS deployments in Europe and in the USA indicate that "pilot projects are critical to driving change" because they "allow local governments and private companies to adapt regulation frameworks, improve service operations, and foster a culture of change across organizations" (Terrien et al., 2016, p. 30).

It is common to see cities organizing pilot projects for the deployment of FFCS. First, to understand the characteristics, and then to be able to regulate for it in a way that is compatible with the local usage, profile and impacts. Examples of these cities, where pilots are in different stages of development, or already over, are:

- San Francisco
- Portland
- Seattle (recent with Lime, discontinued in 2019)
- Chicago (recent with Car2go, impacted by the company's decision to stop operating in the city from Dec/19 on)
- Montreal
- Toronto (trial with Communauto that started after Car2Go left and was recently approved)
- Munich
- Grenoble (Cité Lib by Ha:Mo - concluded)

Key findings 2

Final thoughts on the key issues to consider when implementing FFCS

Car sharing (and MaaS) relies on conventional infrastructure for private cars, like car parking spaces, and can itself encourage car use - 'hell' (Chase, 2014). Alternatively, car sharing can help to reduce car ownership, and potentially use, reducing sunk costs, and unbundling the ownership from the usage. With fewer sunk costs and less personal ownership (hybridisation), cars may be treated as more utilitarian or instrumental forms of transport. For example, the more efficient use of space and vehicles, and the reliance on data, allows for a demand rather than a supply-based approach to parking policy and potentially for the reduction of space allocated to car storage. Best case - 'heaven' (Chase, 2014) - predictions of the impacts of MaaS and autonomous cars tend to hinge on the idea that less car parking will be required.

Marsden et al (2020) argue that "governments need to develop a clear multi-use and multi-user framework for thinking about streets which ensures that regulatory recodification is properly thought through and allocates rights to maximise wider public goals". A recent Centre for London (2020) report considered the "value of alternative uses of kerb space", beyond a tendency to prioritise private residential car parking, and recommended developing "kerbside strategies that allocate road and kerb space in accordance with clear use hierarchies". FFCS and the parking policies that can be used to support or manage it are an example of the need for such policies. In the short term, technology and sharing platforms mean that existing car parks are already being used in new ways and putting pressure on existing ways of allocating space that tend to privilege private car ownership (Marsden et al 2020). MaaS and other technologies push up against existing approaches to car parking. Various authors urge that policy needs to clarify if and why a hierarchy of permits applies and on what basis.

Success factors of FFCS - According to Schiller et al. (2017, p. 3), "in order to be successful, free-floating providers need to consider the following success factors:

- *Location: high population density to attract sufficient customers per car.*
- *Pricing: based on time (mostly per minute), not distance.*
- *Cooperation: local authorities have to grant parking spaces / permits.*
- *Convenience: constant availability of (small) cars that fit needs in city areas".*

FFCS in Australia

Currently, car sharing operations in Australia do not include FFCS services yet. Brisbane City Council has recently released a type of permit to allow car sharing, or “short-term hire” operations in the city that enables the operation of FFCS. When released, these permits are connected to the vehicles and are “valid for use in any regulated parking permit scheme area” (Brisbane City Council, 2019).

The geographic characteristics of Brisbane City Council suggest that an FFCS operation would be less challenging than in other Australian main cities to design and manage for the actors involved. The reason for this assumption is that the shape and size of the boundaries of the Council seem more suitable for a service area, and thus would reduce the need to negotiate with several LGAs to come up with a final arrangement. Nevertheless, this assumption needs to be validated with an actual trial or deployment of the service.

Predicting the impacts that FFCS services would have in Australian cities is still a difficult exercise. Evaluating local operations would make this task more feasible, but the current lack of official FFCS deployments in the local context pushes this task to future opportunities. In addition, further academic research is needed on the topic, in general and in Australia, to help with these conclusions - particularly amidst recent and ongoing transformations in the terrain of new mobilities and FFCS. However, experiences from other cities with FFCS operations, like the ones presented in this report, can teach valuable lessons about common and mostly appointed issues related to the implementation of this type of car sharing.

Recommendations – FFCS implementation checklist

Considering the role of local governments in a proper (beneficial to the city or region) implementation of new mobilities and in the creation of more sustainable urban environments, it is paramount to explore the relationship between FFCS and policies, or why governments need to deal with this transport mode (London Councils, 2020; Paganelli, 2019, 2013; Terrien et al., 2016). Based on research and analyses of global deployments performed for this study, some recommendations for Australian cities to deal with possibly challenging local implementations of FFCS are:

- **Information –** Knowledge about the concept of car sharing in general, especially how FFCS works, among policy makers and citizens.
- **Local Characteristics –** Crucial understanding of local characteristics and potentials before regulating for FFCS, i.e. knowledge about the travel behaviour of local residents.
- **Space Allocation –** Definition of a service area for FFCS operation considering it is likely that vehicles wll be used in between LGAs around Australia. Therefore, cross-council negotiation, collaboration and data sharing are paramount to define regulatory systems.
- **Experimentation –** Experiments and the development of pilots or trials to test how a local deployment of FFCS would be and understand its potential impacts.
- **Curb space management –** Creation or adaptation of strategic parking and curb space management systems, considering how parking spaces will be allocated for FFCS vehicles and what legal instruments are required.
- **Data sharing –** Development of a data sharing and evaluation system to measure the local impacts of FFCS and check if the results are achieving the city's goals.

Conclusions

This report offers a collection of materials about urban mobility, governance and car sharing (FFCS), focused on an Australian context, that may support government and industry in enabling best practice applications of car sharing in their jurisdictions.

As demonstrated here, FFCS works differently in cities around the world and success depends on a mix of characteristics. However, the common challenge is to ensure it will be beneficial to these urban environments. For local governments, before implementing or creating support systems for FFCS to operate, it is crucial to understand the impacts of this mode in their cities, to ensure that it will bring benefits instead of competing with existing public and active transport systems. And that is why pilots and experiments are powerful tools. This process usually requires rethinking how urban space (kerb space) will be used, and the way parking will be allocated, procedure that makes local authorities consider the changes and discuss about how to implement them. In some ways, this exercise may trigger positive transformations in the planning and evaluation processes.

The findings presented in this report reinforce the value of initiatives like this project to build awareness, engage relevant actors, and provide an evidence base to help local governments and industry create appropriate environments for FFCS in their cities, if this is their goal or if companies launch locally. The results may enable local planners to make more informed decisions about what role FFCS could realistically play in their urban environments and provide them with levers to define mechanisms for strategic FFCS deployments.

To conclude, recent global shutdowns and the continued volatility of FFCS operations help to illustrate the uncertainties over future demand for urban space and how best to manage it. Moreover, the current unpredicted COVID-19 crisis, followed by its devastating and forthcoming, but still unclear, consequences is exacerbating the complexity, pressure (especially over CSOs, local authorities and decision makers), and, perhaps, anxiety, that has permeated terrains like transport and urban planning in cities worldwide for several years.

It remains to be seen how the already vulnerable and uncertain future of car sharing, and transportation in general, will be after the prevailing changes. Yet, crises and societal shocks can enable positive change, and may instead offer opportunities to positively reinvent urban mobility.

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