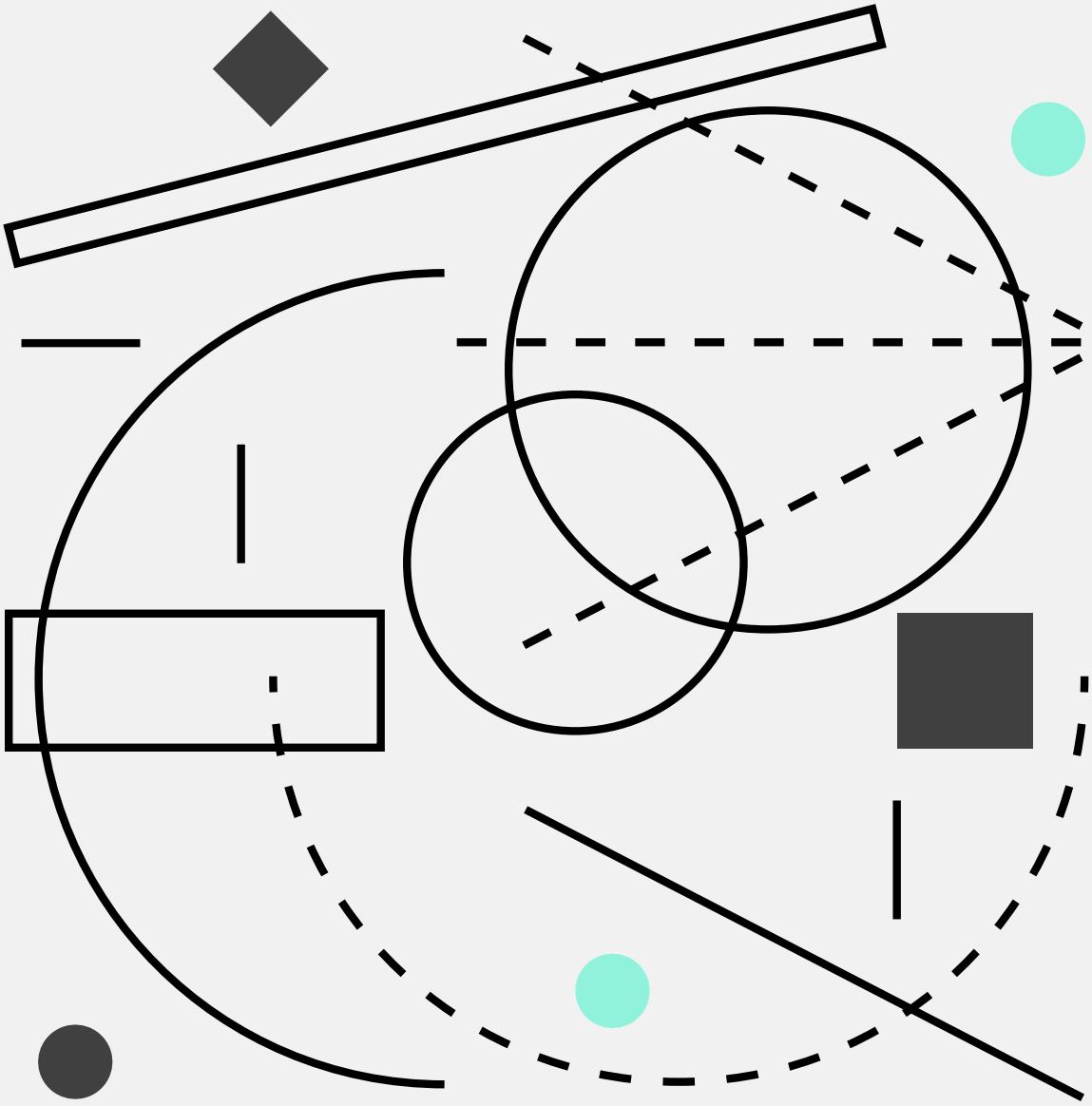
DISCUSSION PAPER

JUNE 2019

Openness in Mobility Transformations for Zero Emissions Cities



Open Source Lab
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Any views expressed in this report are those of the author and do not necessarily reflect those of the project partners.

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About the Open Source Lab

The Open Source Lab for Sustainable Mobility is a Think Tank project based in Berlin, Germany. It was established by the Volkswagen Sustainability Council and is implemented by the German Research Center for Artificial Intelligence. In addition to supporting the Sustainability Council, the Lab serves to facilitate a broad public dialogue on sustainable mobility involving a range of stakeholder groups. Utilising design research methods, the Lab provides an open platform for interdisciplinary research and knowledge sharing.

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Executive summary

This Discussion Paper outlines issues and opportunities for open approaches in mobility transformations to enable zero emissions cities. It provides an overview of matters related to mobility behavior, current mobility transformations and new mobility governance.

Urban mobility plays a key role in enabling cities to reach the goal of carbon neutrality. The accomplishment of sustainable mobility requires a range of transport modes and infrastructure for the movement of people and goods, built environments conducive to active mobility, the emergence of Mobility as a Service (MaaS), as well as behavior change of citizens. It involves a range of stakeholders meeting different aims together as part of systems-level initiatives.

To facilitate sustainable mobility behavior, convenience, cost and speed are pivotal. Balancing these depends on the stage of life and values of the transport user. Information based programs and transport service provision should be targeted to address an array of needs. With new mobility solutions significant amounts of data will be generated. This could inform activities to improve public transport service provision or to positively influence travel behavior. However, location data is highly sensitive and data privacy must be ensured. Lack of public trust in mobility service providers or overarching data governance could preclude user uptake of more sustainable mobility modes.

Mobility as a Service (MaaS) is changing the nature of mobility in cities. However, MaaS providers sometimes move quickly without collaborating with governments or prioritizing openness in their operations. In some cities the benefits advocated by MaaS are being contested. Joint-working and constructive mobility data collection and sharing between mobility service providers and government is needed to ensure zero emissions city progress.

Open approaches such as open standards, open data and open source code enable innovation and the creation solutions beyond what can be achieved by a single organization. Both governments and private organizations could utilize open approaches for better informed decision making, product and service offerings as well as to elevate accountability and public trust. Open data has significant potential to strengthen sustainable mobility transformations.

The nature of mobility is transitioning from the state being the prime source of public transport and information to it being one of many actors providing services, infrastructure and information into the mobility system. In each city or region the subject government and its constituents must determine how this transition is to be managed, including the assessment of new mobility concepts, their physical manifestations in urban environments and how they should be governed. Whilst regulation and policy will vary by context and involve multiple levels of government, alongside partnerships they will be integral to forging ways forward that achieve sustainable mobility ecosystems whilst elevating the public good.

Introduction

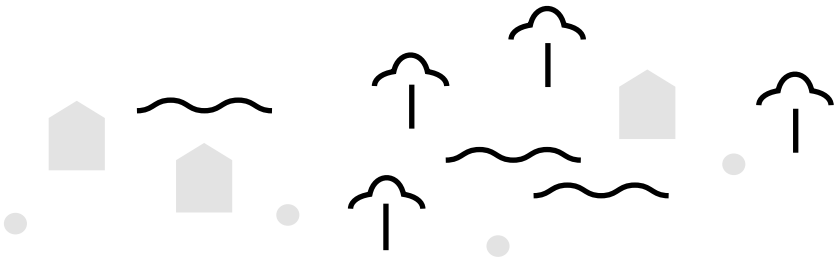
The challenge of zero emissions cities

Despite the Paris Agreement and ambitious zero carbon programs of many cities, in 2018 global carbon emissions continued to increase and reached an all-time record high.[1]

Achieving carbon neutral cities involves transitions of city's physical form, functions, supporting infrastructure and systems. Transitions needed to enable zero emissions cities include energy transition to renewables, built environment density and mix of uses, waste and consumption minimization, building performance standards, integration of ecological elements and systems into the built environment (green zones, vegetation, tree plantings, green roofs and facades), as well as sustainable mobility and logistics. Zero carbon cities require decoupling of urban resource flows as well as infrastructure transformations to enable new cross-sector systems synergies. For example, energy capture, storage and supply between electrified transport, district heating and industrial networks.[2]

Source: Institute for Sustainability (2017) https://www.instituteforsustainability.co.uk

The Sustainable City



New governance and financial planing

Integrated planning and investment

Community-owned change

Smart logostic and green supply chains
Smart grids
Resource efficient buildings
Sustainable transport
Water efficiency
Community-owned infrastructure
Remanufacturing and upcycling
Retrofitting existing buildings
Employment opportunities
Renewable energy at community level
Waste to energy plants
Behaviour change
Green space

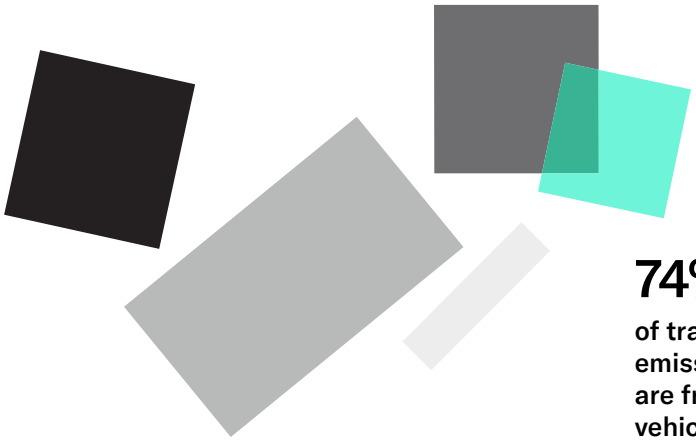
1 C40 Cities (2019) www.c40.org/cities and Global Carbon Budget (2018) https://www.globalcarbonproject.org/

2 UN Environment International Resource Panel (2019) *City-Level Decoupling.* http://www.resourcepanel.org/reports/city-level-decoupling Maćkowiak-Pandera, J. (2018) *Linking Sectors. Power, transport, heat united.Heinrich Boll Stiftung.* 24.04.2018. https://www.boell.de/en/2018/04/24/linking-sectors-power-trnsport-heat-united

Sustainable mobility

Approximately a quarter of total global carbon emissions are from transport, with 74% of these originating from road vehicles.[3] Vehicle emissions are being amplified by growing passenger miles coupled with the rise of urban freight journeys to enable burgeoning e-commerce demand for expedient door-to-door delivery of goods and supplies to households and businesses.

Global CO^2 Emissions by Sector



Source: International Energy Agency (2016) https://www.iea.org/statistics/co2emissions/

There are reportedly 12 cities in Europe and North America that have reached 'peak carbon' and reduced their emissions. However, there are more than 1,860 cities around the world with a population

3 International Energy Agency (2018) *CO2 Emissions*. https://www.iea.org/statistics/co2emissions/

of more than 300,000 people.[4] Consideration of all cities globally reveals that as much as 80% of them exceed the World Health Organization's air quality standards, with the transport sector being a major contributor.[5] Traffic congestion costs cities billions each year due to loss of worker productivity from commuting, higher road transportation costs and the fuel burned by stationary vehicles.[6]

In light of these impacts, an increasing number of city governments are introducing congestion charging, banning diesel engine vehicles as well as creating car-free areas or schedules.[7] These changes seek to elevate sustainable mobility modes to become the preference for city dwellers over private vehicles and to maximise the efficiency of urban freight logistics. More sustainable options include public transport to taxi, car sharing, carpooling, bike sharing, shared scooters, cycling and walking. The components of a sustainable mobility network vary according to each spatial context. Land uses, fixed and planned physical transport infrastructure, policies and regulations, the landscape of service providers and demographic characteristics are some of the factors. These determine the combination of transport modes and design viable for a city's mobility transformations.

Sustainable mobility is achieved when a transport network is "able to meet the needs of society, which include the ability to move freely, gain access, communicate, trade and establish relationships

4 UN (2018) *The World's Cities in 2018.* Data Booklet. https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf

5 WHO (2018) *9 out of 10 people worldwide breathe polluted air, but more countries are taking action.* https://www.who.int/news-room/detail/02-05-2018

6 INRIX (2018) *Global Traffic Scorecard.* http://inrix.com/scorecard

7 Bendix, A (2019) *15 major cities around the world that are starting to ban cars.* https://www.businessinsider.de/cities-going-car-free-ban-2018-12

Sustainable mobility involves a range of stakeholders meeting different aims together as part of systems-level initiatives that steer urban mobility and cities towards a zero carbon future.

without sacrificing other essential human or ecological values today or in the future."[8] It involves a range of stakeholders including materials suppliers, vehicle manufacturers, IT companies and transport users meeting different aims together as part of systems-level initiatives that steer urban mobility and cities towards a zero carbon future.

In any urban context, the design of streets to be safe and pleasant plays a central role in providing attractive options for people to choose zero and low carbon options. Urban design and planning to enable non-vehicle journeys is a long established practice by city governments, as testified over recent decades by urban planning and design principles of new urbanism, smart growth or the complete streets movements.[9] The current surge of interest in 'smart cities' extends on these paradigms with additional emphasis on the application of new technologies, and in particular data capture and analysis techniques, to enable more effective urban governance for achieving urban quality, safety and service provision.

Electric vehicle charging points, micro-mobility, allocated pick-up and drop-off zones for ride hailing and delivery services (including autonomous vehicles) as well as dedicated car sharing spaces are standard elements that will characterize the 21st century street for a sustainable mobility ecosystem. Future mobility ecosystems will also have unprecedented information supply. User friendly, real time reporting about all transport options and routes, fares, parking and traffic flows and modal patronage volumes will be enabled by mobility network's data capture.

8 WBCSD (2001, 2004) in Nijhuis, Y. (2013) *Consuming mobility. a practice approach to sustainable mobility transitions.* Wageningen Academic Publishers; Wageningen. pp. 30

9 Zehngebot, C & Peiser, R. (2014) *Complete Streets Come of Age.* Planning. May 2014 Issue. https://www.planning.org/planning/2014/may/completestreets.htm

Mobility behavior

MOBILITY NEEDS

How can people be encouraged to adopt sustainable mobility behavior?

In order to encourage sustainable mobility behavior, provision of affordable low and zero carbon options must be in place. Even in cities of apparent mobility abundance, such as New York, London or Berlin, there are transit deserts and urban areas with an absence of sustainable mobility infrastructure and services whereby individuals simply do not have mobility choices outside of private vehicles.

Where density and market demand exists, mobility options in post-industrial cities are increasing with public and private service providers competing for journeys. Sustainable mobility is a *lifestyle challenge* in rich countries. In these contexts people don't want to think about mobility choices. Mobility has to be convenient, cheap and fast (Saadya Windauer, Open Knowledge Foundation and 2030 Watch). Given an array of options, people generally prefer to minimise commute times due to a negative correlation between life satisfaction and the amount of time spent commuting. Companies are responding to this desire of most to minimise, or even preclude, the need to travel to work each day, and remote working is becoming a workplace norm.[10]

10 Li, D. (2018). *Introducing your commute on LinkedIn Jobs.* 07.06.2018. https://blog.linkedin.com/2018/june/7 Carmela, S. (2018) *Communication Technology and Inclusion Will Shape the Future of Work.* 27.12.2018. https://www.businessnewsdaily.com/8156-future-of-remote-work.html

An emphasis on convenience is highlighted by user research concerning the UbiGo transport broker service developed in Gothenburg, Sweden. The digital mobility platform pilot included a rewards system for more sustainable travel behavior. It was found that early users are initially motivated by curiosity, but that this must be transformed into more practical motivations such as convenience and economic advantage if they are to remain motivated to using the service. “Concern for the environment functions as a bonus rather than a primary motivator, meaning that the environmentally friendly choice must also be the practical choice in order to promote sustainability... the service cannot be perceived as economically disadvantageous, inflexible or inconvenient, or difficult to use; and the alternative transportation infrastructure must be extensive enough to reach the users.”[11]

Sustainable mobility is a lifestyle challenge in rich countries. In these contexts people don’t want to think about mobility choices. Mobility has to be convenient, cheap and fast.

In order to determine the most ‘practical choice’ an array of variables are considered. In a city with a range of transport modes and services, an individual determines their choice of mobility for each individual journey by consideration of factors that might change each day. Personal values, tastes and goals are taken into account. These could include potential for enjoyment, exercise or relaxation, the number of people travelling together, the weather, the activity at the end journey point i.e. need to carry goods or luggage, or the user’s overall schedule for the day.

In addition to day to day mobility needs changing, requirements for journeys are also shaped by stages of life. For example sustainable transport options

11 Sochor, J. Strömberg, H & Karlsson, I.C. (2014) *Traveller’s motives for adopting a new, innovative travel service. Insights from the Ubigo field operational test in Gothenberg, Sweden.* 21st World Congress on Intelligent Transportation Systems, Detroit, September 7-11, 2014 http://publications.lib.chalmers.se/records/fulltext/204386/local_204386.pdf

may be viable for a lone travelling adult, but not appropriate when they have children or elderly family members to care for. A range of mobility interventions are needed that address the different needs of people at different stages of life. We cannot expect people to use a sustainable option when there is only one inconvenient sustainable option available (Beate Kubitz, TravelSpirit Foundation).

When considering transport options (if they exist), it might be difficult for individuals to make informed choices due to lack of information on mobility possibilities or the potential impacts of choosing different forms of transport. In addressing this, any policies or programs aiming to change mobility habits of a given population must consider that mobility behavior is most likely to change amongst those that already care about CO2 emissions (Aneeque Javaid, Mercator Research Institute on Global Commons and Climate Change). Those that are not concerned with carbon emissions provide the challenge to try new forms of transport because they have no established motivation to change their behavior. These groups need highly relevant, clear information on different options according to their transport needs, preferences and possible benefits in relation to their values. It can also be beneficial to enable people to compare themselves with others; this encourages discussions about the status quo as well as alternative possibilities (Saadya Windauer, Open Knowledge Foundation and 2030 Watch).

Depending on the audience, communication about sustainable mobility options may need to be provided alongside information about a much broader set of mobility related issues. For instance, in addition insights about carbon emissions sources and

Targeting information according to the known attitudes and preferences of a given group can positively affect mobility behavior.

impacts, other themes that affect mobility choice could be data privacy, safety, democratic rights or health risks from inactive lifestyles. Targeting such information according to an individual's attitudes and preferences can be an effective mechanism to positively influence mobility behavior.[12]

Information based programs to positively influence mobility behavior are more likely to resonate when a change in life circumstances occur. At times when life is in flux mobility habits are interrupted and new options considered. For example, when entering the workforce, having children, moving to a new location, or experiencing reduced physical capacities. During these readjustments individuals are likely to consider new options for mobility and adopt more sustainable mobility habits if zero or low carbon options meet their (new) needs.

12 Semanjski, I. & Gautama, S. (2016) *Crowdsourcing mobility insights - Reflection of attitude based segments on high resolution mobility behaviour data.* Transportation Research Part C: Emerging Technologies. Volume 71, October 2016. pp. 434-446

DATA AWARENESS AND TRUST

What issues surround mobility data and do people care about the data they generate?

Mobility data involves any information collected about a person's transport journeys that can be captured, processed and stored digitally. It could include travel times, type, behavior during trips, locations and purchase information. This makes mobility pertinent to current debates surrounding the data economy of which the generation of data, by and about individuals, has become a valuable resource and market in itself.

Data is generated by individuals both actively and passively, in private and public spaces, through real world activities and virtual ones online.

In cities of advanced economies, realms of data is generated by individuals both actively and passively, in private and public spaces, through real world activities and virtual ones online. Actively, data is generated through one's choice to input information digitally, take part in a regular activity such as purchasing goods or services, or simply visiting physical or virtual locations. Passively, individuals are the source of data created when third parties indirectly collect information about one's activities, interactions and behavior, correlate and aggregate it with other sources and create data based products and services.

For instance, one quantification of data generation is that global internet users are the source of about 2.5 quintillion bytes of data each day.[13] Consequently, there are over 7,000 marketing technology companies whose core business is based on tracking, acquiring, merging and analyzing online data to enable targeted advertising campaigns and other data based services.[14] Much of these activities have been undertaken without the knowledge or explicit consent of the individuals that are the source of the data with their online input and behavior. The Cambridge Analytical scandal (2017), adoption of GDPR data protection legislation in Europe (2018) and subsequent broad reportage of data privacy breaches or non-transparent use by both private companies and governments have raised public awareness and debate around data collection practices and their potential impacts on privacy, human rights, civil liberties and democracy.

Whilst people increasingly indicate that they are concerned about the privacy of their data, they commonly undertake behaviors contrary to this concern.[15] This phenomenon is referred to as the privacy paradox. Mitchell and Kamleitner (2018) propose that the privacy paradox occurs because people generally do not feel a sense of ownership over their data. It is intangible and difficult to define and is not seen as something that can be successfully protected. That little to no effort is needed to generate personal data, as well as lack of knowledge about all the sources of its collection, are

13 Desjardins, J. (2019) *How much data is generated each day.* 17.04.2019. https://www.weforum.org/agenda/2019/04/how-much-data-is-generated-each-day

14 Brinker, S. (2019) *Marketing Technology Landscape Supergraphic.* Chief Marketing Technologist. 04.04.2018. https://chiefmartec.com/2019/04/marketing-technology-landscape-supergraphic-2019/

15 Kokolakis, S. (2015) *Privacy attitudes and privacy behaviour. A review of current research on the privacy paradox phenomenon.* Computers and Society. July 2015. https://www.researchgate.net/publication/280244291/

also key influences.[16]

In light of the difficulties in conceptualising and managing one's data, many have become digitally resigned. People want to control the digital information companies have about them but feel unable to do so.[17] The Open Data Institute considers that digital resignation can be differentiated amongst consumer groups. For some people it is based on a feeling of helplessness, others are comfortable with losing privacy for convenience or to access services, whilst others don't fully understand the use of their data or what they can do about it. The group of people who don't understand seems to be shrinking as people move into the other groups and solidify their opinions. However, there is likely a baseline of people who will never understand (Peter Wells, Open Data Institute).

People want to control the digital information companies have about them but feel unable to do so.

The growth of the Internet of Things (IoT) with connected devices and sensors in both public and private spheres of cities will cause data collection capabilities of companies and governments to exponentially increase in the coming decades.[18] In line with this, all technology based sustainable mobility solutions involve data collection to some extent, such as for route calculation, public transport ticketing or to enable convenient micro-mobility or car sharing offerings. Both privately owned and shared cars will collect data on any environments they traverse through their sensors, as well as accumulate passenger data through vehicle's

16 Kamleitner, B. & Mitchell, V.W. (2018) *Can consumers experience ownership for all their personal data. From issues of scope and invisibility to agents handling our digital blueprints.* In Joann Peck & Suzanne Shu: Psychological Ownership and Consumer Behaviour. Springer.

17 Turow,J. (2019) *The corporate cultivation of digital resignation.* https://www.researchgate.net/publication/331618712_The_corporate_cultivation_of_digital_resignation New Media & Society. March 2019.

18 Columbus, L. (2018) *2018 Roundup of Internet of Things Forecasts and Market Estimates.* 13.12.2018. https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018

infotainment and passenger monitoring systems. Reflecting upon what has occurred with the optimisation of online behavioral data, cities and mobility providers must prepare for the emergence of urban data economies.

New mobility formats will accumulate significant amounts of location data, which is the most sensitive type collected. Shared and micro mobility journeys are often made door-to-door making them easier to re-identify an individual person compared to data collection from public transport modes. Even when location data is anonymized, the combining of location-stamped data makes it easier to discern identities.[19] For instance, the personal identity of someone can be established with data from as little as four door to door journeys.[20] This is a key justification that MaaS providers assert for non-disclosure of their data to city governments. Given the expected growth of new mobility services and the need of city governments to ascertain aspects of their data for transport planning and management, joint-working and constructive mobility data collection and sharing between these parties is needed to ensure zero emissions city progress.

Lack of public trust in mobility service providers or overarching data governance could preclude user uptake of new sustainable mobility solutions.

Lack of public trust in mobility service providers, data capture or overarching data governance could preclude user uptake of new zero or low carbon mobility solutions. It might also provide a barrier to city governments ability to use of transport data to appropriately regulate mobility providers. If cities and public transport agencies could access more data on transport user's journeys and mobility patterns,

19 Massachusetts Institute of Technology (2018) *The Privacy Risks of Compiling Mobility Data.* https://www.sciencedaily.com/releases/2018/12/181207144403.htm

20 Clewlow, R. (2018) *The Opportunity To Reshape Cities With Shared Mobility Data.* Forbes 10.10.2018. https://www.forbes.com/sites/reginaclewlow/2018/10/10/the-opportunity-to-reshape-cities-with-shared-mobility-data

targeted service planning and the expedient meeting of critical shortfalls could be achieved.

Levels of trust vary in different countries and over time. For example, privacy concerns in Germany have limited the government's ability to share data. Conversely, in the United Kingdom pressure for greater transparency has prompted the increasing release of government data. Even within countries public trust varies depending on the subject organization or industry sector as well as the type of information in question. Research by the Open Data Institute highlights these complexities in understanding trust people have in sharing their information with different parties.[21] In line with these findings, levels of trust are also likely to vary at the regional or city level, reflecting perceptions of the efficacy of different levels of governance and norms of local economies.

Governments as well as organizations must work towards ensuring public confidence in data privacy and the use of personal data generated actively and passively in the city, including with different forms of transport. There needs to be a range of options for data management and access with opportunities for citizen involvement.

The Open Data Institute has identified an array of potential models that data holders could utilize alone or in combination for transparent and trustworthy data management. Models include Data Trusts, Data Commons, Data Hubs, Data Review Boards, Data Observatories and Open Access Ecosystems. "Organizations looking to implement a data access model will need to make decisions related to

21 Dodds, L. (2018) *Who do we trust with personal data*? Open Data Institute. 05.07.2018. https://theodi.org/article/who-do-we-trust-with-personal-data-odi-commissioned-survey-reveals-most-and-least-trusted-sectors-across-europe/

governance, oversight, enforcement, ethical review processes, technical mechanisms, legal structures and stakeholder engagement."[22] Customisation of these elements to reflect the capabilities and needs of an organization and its stakeholders is a central tenet to enable the model's effectiveness and build user and public trust.

22 Robert Keller, J. (2018) *Data Access Archipelago. mapping the myriad ways we share data.* Open Data Institute 02.11.2018. https://theodi.org/article/data-access-archipelago-mapping-the-myriad-ways-we-share-data/

Mobility transformations

MOBILITY MARKETS

What are prominent trends emerging in the mobility sector affecting the achievement of zero emissions cities?

The global Mobility as a Service industry is forecast to be worth trillions by 2030.

The global Mobility as a Service (MaaS) industry is changing the nature of mobility in cities. Rather than the past binary of private vehicle ownership and public transportation, it provides means to purchase mobility as a service only when needed. MaaS platforms usually provide an intermodal journey planner including combinations of different transport modes e.g. rail, bus, bike-sharing, taxi, as well as a booking system, easy-payment and real time information.[23] Popular modes include ride hailing, car sharing, mini-van shuttles, electric scooters and bike sharing. The industry's value is expected to reach approximately USD$253 billion by 2023 and grow to the trillions later that decade.[24]

To capitalise on this growing industry, emerging private sector mobility service providers sometimes move quickly into new cities without collaborating with governments or prioritizing openness in their operations. As generally with technology based

23 Kamargianni et al., (2015) *Feasibility Study for* " *Mobility as a Service*" *concept in London.* Report – UCL Energy Institute and Department for Transport.

24 Market Watch. (2018) *Mobility as Service* " *MaaS*" *Market 2018.* 14.11.2018. https://www.marketwatch.com/press-release/mobility-as-service-maas-market-2018

Whether MaaS implemented in cities so far is having a positive or negative impact overall is the subject of current debate.

startups, their business models require that they experiment with offerings and scale quickly in their go-to-market strategies to achieve virtuous network effects. Mobility companies are racing to be the primary platform that integrates all transport modes and payment functions in this 'winner takes all' market environment.

However, in some major cities that Mobility as a Service providers have proliferated, the service benefits advocated by MaaS companies are being contested. Paris has banned scooters due to their infringement of pedestrian right of ways and recent studies by cities in the United States have found that ride hailing services such as Lyft and Uber are making traffic significantly worse, taking passenger journeys that otherwise would have been done via public transport, walking or cycling.[25] For example, traffic congestion in San Francisco went up by about 60% from 2010 to 2016 and ride hailing companies are alleged to have been responsible for more than half of that increase.[26] Similarly, a study of Boston found that 42% of trips taken with ride hailing services in Boston would have been completed on public transit had the option not been available. Another 12% of people would have walked or cycled.[27] However, a key problem in assessing the impacts of MaaS is that data is not open regarding their vehicle movements and usership.[28]

Setting aside emerging debates about the actual impact of certain types of MaaS businesses, another

25 Dillet, R (2019) *Paris clamps down on scooter startups.* 06.06.2019. https://techcrunch.com/2019/06/06/paris-clamps-down-on-scooter-startups/

26 Erhardt, D. Roy, S. Cooper, D. Sana, B. Chen, M. & Castiglione, J. (2019) *Do transportation network companies decrease or increase congestion.* Science Advances. 08 May 2019. Vol. 5, no. 5.

27 Gehrke, S. Felix, A. and Reardon, T. (2019) *Fare Choices. A Study of Ride-Hailing Passengers in Metro Boston.* Metropolitan Area Planning Council Research Brief. February 2018.

28 Marschall. A. (2018) *Dying for Uber and Lyft's secrets, data-hungry cities get creative.* 03.08.18. https://www.wired.com/story/uber-lyft-data-research-driver-pay/

issue is the absence of these services altogether in locations outside of major city central areas. Financial viability of Mobility as a Service is not favorable in the suburban neighborhoods of larger cities, smaller cities and peri-urban catchments. In these locations the introduction of car sharing or ride hailing by public-private partnership could provide more efficient, more reliable and cost-effective transport services than traditional public transport modes and infrastructure if collaboratively implemented and maintained.

Mobility transformations will be driven by autonomous vehicles (AVs) and systems, mapping and navigation platforms, sensor technology, vehicle to vehicle connectivity and fleet management software, mobility services including car sharing, electric charging technology and new finance and insurance capabilities such as blockchain and micro payments. Autonomous vehicle ride hailing fleets, micro-mobility, user friendly multimodal journey planning and ticketing platforms, coupled with cities proactively discouraging private vehicle usage, will see the decline of private vehicle use in major cities and much greater competition for public transport providers.

OPEN APPROACHES

How can openness accelerate transformations needed for sustainable mobility systems?

Open approaches in mobility, such as open standards, open data or open source code, enable local innovation ecosystems that meet the needs of transport users through new businesses and business models beyond what can be achieved by a single transport provider.

The Open Definition Project (2019) defines a piece of data or content to be open if anyone can "freely access, use, modify, and share for any purpose (subject, at most, to requirements that preserve provenance and openness)."[29] When considering the extent of 'openness' in sustainable mobility models, a number of characteristics should be taken into account. These include its accessibility, rights of use, cost and processing format. Table 1 provides some examples of open approaches underpinning mobility solutions that have been implemented or piloted in Europe and the United States.

29 The Open Knowledge Foundation (2019) *The Open Definition.* https://opendefinition.org

Table 1: Examples of open approaches underpinning sustainable mobility solutions

Approuch	Name	Initiator & location	Overview
Open data	Open data users (open data portal)	Transport for London (TfL) London UK	Open transport data released by TfL has led to the development of over 700 Apps e.g. city mapper, station master, accessibility locations, open train times, disruption alerts. Generated approx. £130m in benefits. [30]
Decentral-ised data manage-ment	DECODE	Europe wide public consortium. Amsterdam and Barce-lona	DECODE (Decentralised citizen-owned data ecosystems) is a project funded by the EU to pilot technology based tools that enable people to manage their personal data and share it with city stakeholders if they choose.
Mobility market-place	Mobility marketplace	Public private partnership Denmark	MaaS App developed through. Minrejseplan offers multi-modal options from car and bike sharing to public transport and car-pooling, as well as ticketing. Uses open protocols and API.
	iomob	Startup Estonia	MaaS App based on open source and block-chain technology to decentralize mobility. Provides an interoperable mobility aggrega-tion platform, single payment system and permissionless, global network.
	Digitized mobility — the open mobility platform	Fraunhofer Institute for Applied Information Technology Germany	A technical reference architecture for new mobility business models. Funded by the Federal Ministry of Transport and Digital Infrastructure, its aim is to allow single sign-on, single interface for a range of mobility modes and services.

30 Tarrant, D. (2019) *Open data that transformed the world.* ODI Friday Talk. 1st March 2019. Open Data Institute, London UK.

Approuch	Name	Initiator & location	Overview
Open standard	Shared-Streets	Open Transport Partnership (independent non-profit) USA	Standard focused on street-level information, allowing cities and companies to share data compatible with both proprietary and open-source basemaps. Uber, Lyft and Ford have partnered, sharing information such as vehicle speed data and curbside pickup/ dropoff locations.
	Mobility Data Specification	City of Los Angeles Department of Transportation USA	The Mobility Data Specification is designed to make it easier for cities to ingest and analyze various sources of information. The City focused specifically on rideshare operators, bike share and scooter share companies. [31]

Both governments and private organizations could make more information open to enable better informed and real-time decision making, appealing product and service offerings and to elevate accountability and public trust. Governments capture and share large amounts of data on a range of topics relating to core government activities and the provision of public services. Businesses and other private organizations also have vast amounts of data such as on sales transactions, customer characteristics, shipping patterns, or supply chain sources.

Data is a key driver for economic prosperity across sectors. The Open Data Institute advocate that data should be treated as part of essential infrastructure

31 https://www.smartcitiesdive.com/news/los-angeles-mobility-data-specification-dockless-rideshare/546692/

for cities and society.[32] It can be argued to be a public good, similar to advocacy of the open source software movement.[33] Open data involves making information and resources as open as possible whilst respecting privacy, commercial confidentiality and the public interest. Not everything can or should be open. Open data should be seen as a necessary long term project. It has the power to spurn decentralised, independent innovation led by civil society." (Saadya Windauer, Open Knowledge Foundation and 2030 Watch)

When the government and other stakeholders release data they help companies, agencies, and individuals to develop innovative apps, products and services that seek to provide benefits or address the unmet needs of users. In Europe alone it is estimated that the expected economic benefits of open data in the year 2020 will include 1.7 billion Euros in cost savings for public administrations, 100,000 jobs created and 629 million hours saved in efficiency and productivity.[34] Differences in awareness, cultural values, legal systems, and technical capabilities provide that governments will need to customize their open data programs. How government does so will shape the landscape for openness in the private sector.

32 Open Data Institute (2019) *State of Open Data. 18. Data Infrastructure.*

33 Nagle, F. (2017) *Learning by contributing. Gaining Competitive Advantage Through Contribution to Crowdsourced Public Goods.* Harvard Business School.

34 European Data Portal. (2017) *The Economic Benefits of Open Data.* Analytical Report No. 9.

Open data initiatives in cities have enabled greater innovation and sustainability progress, positively impacting mobility trends.

Open data has significant potential to strengthen sustainable mobility transformations progress. In a trans-Atlantic study of nine cities focusing on mobility and open data initiatives Yadav et al[35] found that open data initiatives in cities have enabled greater innovation and sustainability actions, positively impacting mobility trends. The different domains that open data benefitted include:

- Parking management that saved government costs plus time and money for drivers
- Traffic management that improved safety and lowered traffic congestion
- New Apps for travel planning that improved uptake of public transport in multi-modal journeys
- Increased active mobility via informing people of waking and cycling route quality
- Increased provision and adoption of ridesharing services
- Increased environmental awareness through air quality and emissions information

Enabling Mobility as a Service (MaaS) whereby an array of transportation needs can be satisfied via a user's interaction with a single interface

35 Yadav, P. Hasan, S. Ojo, A. and Curry, E. (2017). *The role of open data in driving sustainable mobility in nine smart cities.* In Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017, pp. 1248-1263. http://aisel.aisnet.org/ecis2017_rp/81

New mobility governance

SUSTAINABLE MOBILITY TRANSFORMATIONS

How can governance enable sustainable mobility transformations in cities?

Emerging technologies will transform how mobility systems in cities and their regions are organised and operate. The nature of mobility is transitioning from the state being the prime source of public transport and information to it being one of many actors providing services, infrastructure and information into the mobility system.[36]

New mobility transitions will include yet to be proven technologies that could improve public health and safety and urban life quality. As with other socio-technical transitions unfolding, different governments and their constituents must determine how the transition is to be managed, including how positive and negative effects of new mobility concepts and physical manifestations in cities will be considered and governed. Whilst regulation and policy will vary by context and involve multiple levels of government, it will be integral to forging a sustainable way forward that elevates the public good.[37] Table 2 provides

36 Docherty, I. Marsden, G. Anable, J. 2018. *The governance of smart mobility.* Transportation Research Part A: Policy and Practice. Volume 115. September 2018. pp. 114-125

37 Pankratz, D. Nuttall, K. Eggers, W. Turley, M. (2018) *Regulating the Future of Mobility. Balancing innovation and the public good in*

an overview of actions and associated governance mechanisms governments could employ to enable the emergence of sustainable mobility ecosystems in cities. The implementation of new instruments (or programs in new contexts) would benefit from initial small scale pilots.

Table 2: Government mechanisms to enable sustainable mobility ecosystems

Activity	Instruments
Support the adoption of sustainable transport innovations that include open approaches, including lowering costs in early stage adoption and new infrastructures	Research and skills development funding, procurement, subsidies, investment, procurement frameworks, mandate open data where appropriate
Meet shortfalls in the provision of fast, reliable and ubiquitous connectivity	Infrastructure investment, subsidies, joint working or partnership with mobility providers
Ensure standards of mobility service operation with interoperability between systems, suitable data management, standardization of laws and enforcement	Open standards, establish a data exchange platform, mandate open data where appropriate
Ensure accountability and public trust in mobility service provision and citizen's rights	Support the development of data access models, mandate open data where appropriate, regulation

autonomous vehicles, shared mobility and beyond. Deloitte Insights. https://www2.deloitte.com/insights/us/en/focus/future-of-mobility/regulating-transportation-new-mobility-ecosystem.html

Activity	Instruments
Provide means for public and private transport providers to complement each other rather than compete	Create a central mobility marketplace and ticketing platform for multi-modal integration, joint working or partnership with mobility providers
Foster cross sector collaboration to enable urban systems transitions e.g. renewable energy, resource decoupling	Research and skills development funding, subsidies, infrastructure investment, regulation
Support the development of civic digital literacy and enforce digital rights	Education funding, procurement frame-works, regulation of activities that affect public spaces

(Source: Adapted from Docherty, I. Marsden, G. Anable, J. 2018. The governance of smart mobility. Transportation Research Part A: Policy and Practice. Volume 115. September 2018. pp. 114-125, Table 1 and Table 2 with additions)

Regulation and policy will vary by context, but will be integral to forging a sustainable way forward for mobility in cities.

Relevant regulations adopted to-date by national governments include Finland's 'Act on Transport Services' which includes provisions on the interoperability of data and information systems, and open data.[38] Many national governments have implemented laws that require government agencies to favour open source software (OSS) over proprietary software in technology procurement processes.[39] In France for instance, this is considered to have been "a cost effective policy lever that countries can use to both create global social value and increase their own national competitiveness."[40]

38 Ministry of Transport and Communications (2017) *Act on Transport Services.* News article 27.10.2017. https://www.lvm.fi/en/-/act-on-transport-services-955864

39 Center for Strategic and International Studies (2008) *Government Open Source Policies.* https://csis-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/media/csis/pubs/0807218_government_opensource_policies.pdf

40 Nagle, F. (2019) *Government Technology Policy, Social Value, and National Competitiveness.* Working Paper Summary 22.04.2019. Harvard Business School. https://hbswk.hbs.edu/item/government-technology-policy-social-value-and-national-competitiveness

Another key mechanism utilized by governments will be partnerships. Partnerships have the potential to make public transport more attractive and competitive through the provision of new mobility interventions such as dynamic trip-planning and ticketing services; on-demand minibuses and first- and last-mile ride sharing services.[41] Partnerships to establish shuttle or ride hailing services addressing the last mile problem have begun to emerge in some low density areas or small cities.[42] In these cases it is important the agreement adopts an open approach whereby the company is required to provide data to the government partner to inform policy making, urban planning and investment activities.

41 Canales, D., Bouton, S., Trimble, E., Thayne, J., Da Silva, L., Shastry, S., Knupfer, S., Powell, M. (2017) *Connected Urban Growth. Public-Private Collaborations for Transforming Urban Mobility.* Coalition for Urban Transitions. London and Washington, DC. https://newclimateeconomy.report/workingpapers/workingpaper/connected-urban-growth-public-private-collaborations-for-transforming-urban-mobility/

42 https://www.radionz.co.nz/news/national/377315/affluent-suburb-to-receive-publicly-funded-ride-sharing-service and https://www.aljazeera.com/news/2018/12/careem-launches-bus-booking-service-egypt-181204103909764.html

Open data

With digital technologies governments can now readily create collective intelligence — facts and experiences contributed by a large group, community, region, city or nation alongside data from multiple sources — to produce better ideas, more inclusive decision making, and greater accountability and transparency in activities affecting the public good.[43] In line with this, cities have been increasingly seeking to produce data, analyse and mobilise it to improve local services and inform public policy, city planning and urban management. Referred to by some as the informed cities paradigm,[44] it makes more effective urban governance possible through utilisation of data concerning the city and its citizens.

With new mobility solutions, cities have an opportunity to utilize data from fleets of vehicles (bikes, scooters and cars) and transport providers to create data-driven policies and effective investment decisions for zero and low carbon transport modes.[45] With more detailed information about the movements and usage of all types of transport, city governments can reduce the duration of the planning cycle with informed and agile decision making.[46] This could more effectively expand access to mobility in underserved areas and better determine where to invest in improving shared mobility infrastructure such as parking, pick up and drop off zones, and electric charging point locations. Mobility also has

Cities have an opportunity to utilize data from fleets of vehicles and transport providers to create data-driven policies and improve investment decisions.

43 Saunders, T. & Mulgan, G. (2017) *Governing with Collective Intelligence.* Nesta. www.nesta.co.uk/documents

44 Acuto, M., Parnell, S., & Seto, K. C. (2018). *Building a global urban science.* Nature Sustainability, 1(1),

45 https://www.citylab.com/transportation/2019/01/public-transportation-problems-sustainable-mobility-data/580684/

46 Semanjski, I. Bellens, R. Gautama, S. Witlox, F. (2016). *Integrating Big Data into a Sustainable Mobility Policy 2.0 Planning Support System.* Sustainability Journal 2016, 8 (11) pp. 1142-54

a significant impact on other challenges of cities including housing affordability. Greater accessibility for more areas of the city enables a greater array of people to live in areas that are affordable and accessible to most of the city.

For example, Los Angeles County Metropolitan Semanjski, I. Bellens, R. Gautama, S. Witlox, F. (2016). Integrating Big Data into a Sustainable Mobility Policy 2.0 Planning Support System. Sustainability Journal 2016, 8 (11) pp. 1142-54

Transportation Authority utilized location data from 5 million cell phones to enable planning for a more user oriented bus network, to improve bus patronage and ensure effective use of the city's resources.[47] In Canada, City officials in Edmonton use application-programming interfaces and real time updates to analyze the city's performance on a variety of metrics ranging from public transit on-time performance, utilization of public spaces and emergency call-response time. With this, researchers can visualize more than 400 data sets. Another example is the government of China requires car manufacturers to share location data of electric vehicles to more effectively manage traffic flows.[48]

Government utilization of data to improve decision making, service provision and urban management might take different forms (Diagram 2). For instance it might provide data to stakeholders, analyse data from various sources to inform its service provision and operations, and create data policy for its own activities or to frame the state of play in civil society.

47 Rogers, A. (2019). *LA's plan to reboot its bus system - using cell phone data.* Wired 22.04.2019. https://www.wired.com/story/future-of-transportation-los-angeles-bus-cell-phone-data/

48 Kinetz, E. (2018) *In China, your car could be talking to the government.* Associated Press 30.11.2018. https://apnews.com/4a749a4211904784826b45e812cff4ca

Diagram 2: Governance to enable and utilize open data

Provider • Capture and release data • Improve data provision quality	Catalyst • Build an open culture (from within) • Foster stakeholder collaboration • Champion the movement
User • Utilize analytics to improve decision making, offerings and accountability • Invest in skills development and digital tools	Policy maker • Create policy for internal and external use • Establish standards for data quality and format

Source: Adapted from Chui, M. Farrell, D. and Jackson, K. (2014) How government can promote open data. McKinsey. Government designed for new times (with additions)

As part of open data governance, there needs to be regulations on the use of data (Peter Wells, Open Data Institute). This includes not only the collection, processing, storage and sharing of data, but also when data should be deleted. Given the amount of data generated even by the most mundane activities of one's everyday city life, there is much data that can or should simply be deleted by default. The 'right to be forgotten' of the European data protection legislation (GDPR) does somewhat address this issue. However, it is a subject of debate whether this in today's networked society is actually achievable and legally enforceable.

Standards

Sustainable mobility transitions in cities require systems level change based on cross-sector collaboration as well as the multi-scalar implementation of effective sustainable transport solutions. Standards set out requirements, specifications, guidelines or characteristics that can be applied by different parties consistently to ensure that products, processes and services are fit for purpose.[49] They are integral to urban digitisation and Smart Cities progress and are an essential basis for international trade.[50] The interoperability between actors and industries created by standards provide a number of positive effects including increased efficiency, reduction of risk, scalability and healthier competition.

Standards represent consensus; they enable joint-working, scalable innovation and virtuous synergies to emerge.

Open standards are available for anyone to access use or share.[51] If government is to provide or require sharing of mobility data, open data standards set out what and how data should be shared. These standards would include protocols on the format of data, use of anonymisation and which data fields are shared across entities. For a city's mobility actors such as government, public transport and MaaS providers as well as startups based on mobility information, standards represent consensus between parties. They enable joint-working and virtuous synergies to emerge. With new technologies an individual provider might use a new self-developed

49 International Organisation for Standardization (ISO) (2019) *Standards.* https://www.iso.org/standards.html

50 DKE Deutsche Kommission Elektrotechnik. (2015) *The German Standardization Roadmap. Smart City. Version 1.1.* DIN e.V. https://www.din.de/blob/62908/0584b8ddb3764cdac7e855ac3abdf4da/smart-cities-roadmap-en-data.pdf

51 Open Data Institute (2019) *What are open standards for data.* http://standards.theodi.org/introduction what-are-open-standards-for-data/

standard.However, at best this is a potential or proposed standard.

To what extent governments should take part in developing standards is a subject of debate. Some argue the development of standards should be left entirely to the market, whilst others advocate that the government play an active role to ensure the timely development of standards before too many proprietary solutions proliferate. Another consideration is the role of the biggest national markets around the globe who might develop their own standards independently with little need to adopt a globally oriented approach (Michael Sommer, VW Sustainability Council). If the government is seeking to incite industry progress, mandating a solution too early could stifle innovation. It is typical for the market to experiment with divergent solutions before standardising. It provides opportunity for market validation, as well as the kind of rapid iterative development which is harder to conduct while developing a standard (Olivier Thereaux, Open Data Institute).

Whilst multiplication of incompatible solutions can be counterproductive to establishing a standard quickly, the question is when to try and harmonise the solutions into a standard either around a market leader or an emerging standard based on the best of the existing solutions. Any decision a government makes in this space has a large market distorting impact, especially if creating a de facto standard means that one specific actor reaps the rewards of licensing or is given the ability to choose who amongst their competitors they will license to. This is where a government or other convening bodies, such as standard bodies, can push for royalty-free

or FRAND standards ie. to grant access or licenses to interested parties on fair, reasonable and non-discriminatory terms.[52] (Olivier Thereaux, Open Data Institute).

Regulation and policy will vary by context, but will be integral to forging a sustainable way forward with open ecosystems for mobility in cities.

Open data standards are needed to enable the normalisation of data sharing amongst mobility stakeholders across sectors, organizations and government jurisdictions. To ensure timely adoption of standards optimal roles of government would be to favour a solution that emerges in the market, making it a de facto standard, convening the industry to develop a common standard or enforcing the adoption of a standard through regulatory action such as service license conditions.

Open standards that enable city governments to better deliver services include Open311, a protocol being increasingly adopted in US cities for city governments to create interoperable systems for service delivery.[53] CitySDK is an equivalent for Europe focused on participation, mobility and tourism with three corresponding APIs developed.[54]

52 Richter, H. & Slowinski, P. (2018) The Data Sharing Economy: On the Emergence of New Intermediaries. IIC — International Review of Intellectual Property and Competition Law. January 2019, Volume 50, Issue 1, pp 4–29

53 Open311 (2019) *About* http://www.open311.org

54 CitySDK (2019) *What is CitySDK*? http://www.citysdk.eu/about-the-project/

Conclusion

In order to enable greater zero or low carbon mobility uptake, increased data, information and knowledge sharing is needed within government, industry and communities. This includes open information about sustainable mobility modes and journey possibilities (when they exist) according to individual mobility needs and values.

Culture change in both the public and private sectors is needed. Governments can set an example and adopt open source and open data initiatives. Businesses benefit from acting proactively with a leadership driven culture favouring open approaches to incite innovation and be well positioned for future market environments. Utilising open approaches will be an important element of partnerships with government and other vendors for the provision of competitive new mobility products and services.

Stakeholders must find new ways of partnering to optimise the benefits that arise from openness whilst at the same time ensuring that common goals for cities including livability and economic prosperity are achieved. Co-designed models of transport service provision and infrastructure investment can create mutually beneficial solutions in mobility ecosystems. Alongside a range of governance mechanisms including timely open standards, open data, skills development as well as policy and legislation, progress towards zero emissions cities can be ensured.

Openness in mobility transformations for zero emissions cities

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