GECKO

GOVERNANCE FOR NEW MOBILITY SOLUTIONS

Review of end-user perspectives and mobility needs

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LIST OF ACRONYMS

AV – Automated vehicles
B2B – Business to business
B2C – Business to consumer
DV - Driverless Vehicles
EC - European Commission
EU – European Union
GHG – Green House Gas
GPS - Global Positioning System
H2020 – Horizon 2020
ICT – Information and communication technology
MaaS – Mobility as a Service
UAM – Urban Air Mobility

WFH – Work from home

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1. EXECUTIVE SUMMARY

This report contains trends of disruptive innovation and a review of end user perspectives and mobility needs. Within GECKO new mobility solutions end-users include passengers, members of shared services, drivers, and owners, as well as other stakeholders such as pedestrians, cyclists, planners, and policymakers.

As socio-economic trends this report discusses the “decoupling" of economies, rethinking the social contract, work from home, digitalisation, artificial intelligence, e-commerce and demand for goods, and the sharing economy.

Case studies are provided with end user perspectives and mobility needs for connected, cooperative and automated mobility; infrastructure, network and traffic management; MaaS and MaaS platform and shared and on demand mobility.

2. ABOUT GECKO

The rapid proliferation of new technologies and disruptive innovations are taking the world by storm, threatening well established players across many sectors. Regulators and decision-makers at different levels of government are overwhelmed by the challenge, acknowledging that existing frameworks may be inadequate in terms of protecting society, fostering business development and achieving integrated, sustainable mobility.

GECKO's main goal is to support authorities with tools and recommendations for new regulatory frameworks to lead the transition to the new mobility era of cooperative, inclusive, competitive, sustainable and interconnected mobility across all modes, through evidence-based research.

GECKO provides a holistic approach with innovative concepts, methodologies and forward-looking tools to enable this transition to take place, leading to new, adaptive and anticipatory regulatory schemes and balanced governance.

The project aims to build on the strong networks of its partners to ensure solutions are co-designed and validated. Several key indicators and cooperation models will help to develop the Regulatory Frameworks Dashboard (a tool being developed within the framework of GECKO), through which the maturity of given regulations can be judged with respect to emerging mobility solutions.

GECKO will outline an implementation plan including actions required up to 2040 for policy makers to devise regulatory approaches for disruptive innovations and new regulatory frameworks streamlining uptake. GECKO will advise policy makers on challenges and policies that need to be addressed to move towards integrated, accessible and sustainable mobility across modes for both passenger and freight transport.

The project will provide recommendations to policy makers to enable adaptive and anticipatory regulatory schemes and governance with novel policies that contribute to sustainable mobility goals.

3. INTRODUCTION

The term end-user is defined by the Cambridge Dictionary simply as "the person or organization that uses something rather than an organization that trades in it"[1]. This compared to the customer, which is the entity that purchases a product or service from the perspective of the seller.

Within GECKO new mobility solutions end-users include passengers, members of shared services, drivers, and owners, as well as other stakeholders such as pedestrians, cyclists, planners, and policymakers. There can also be considerable heterogeneity within each of these categories, e.g., between early adopters and mainstream users.

This deliverable focuses on end-users as consumers who appropriate products or services, be it for themselves or someone else, such as a family member. This can also be divided into actual adopters (buyers, owners, drivers, passengers, or members) compared to mainstream consumers that have not adopted but are in the potential target market.

Special attention is also paid to the age and gender of the end-user, particularly if they are part of a vulnerable group that experience a higher risk of poverty and social exclusion than the general population. This includes ethnic minorities, migrants, disabled people, the homeless, those struggling with substance abuse, isolated elderly people, and children[2].

[1] Cambridge Dictionary, https://dictionary.cambridge.org/dictionary/english/end-user
[2] European Commission, https://ec.europa.eu/social/main.jsp?langId=en&catId=750

4. TRENDS OF DISRUPTIVE INNOVATION IN MOBILITY

According to the World Economic Forum, the world has entered the Fourth Industrial Revolution, which is driven by seamless automation, endless connectivity and characterised by merging physical and digital advanced technologies such as artificial intelligence, big data analytics, the internet of things, and blockchain. In its scale, scope and complexity, the transformation will be unlike anything humankind has experienced before[3]. This is taking place concurrently with the COVID-19 pandemic in which governments have enforced social distancing and ICTs have facilitated millions of people in working from home during lockdowns, maintaining contact with friends or family. Within this Fourth Industrial Revolution we can see socio-economic trends, such as the following.

4.1. Socio-economic trends

4.1.1. The great disconnection

The "decoupling" of economies had already started pre-COVID-19 with early indicators appearing five to ten years ago, according to some thought leaders, but the pandemic certainly made it more clear how dependence on globalisation could create vulnerabilities[4].
As nations look toward building a new future, it seems likely globalisation is in the rear-view mirror in favour of a multipolar world where there are three or four large regions (America, European Union, China and possibly India) that have distinct economies, security networks, cultures, and laws. These poles would be able to operate from a similar position regarding data privacy, standards, trade agreements, and new mobility solutions[5]. Cooperation between the poles is possible and highly sought after in some areas – such as logistical and supply chains and research activities – where common goods are identified, but not a given and rules of engagement may change according to the participants involved.

4.1.2. Rethinking the social contract

[3] Klaus Schwab. 2017. The Fourth Industrial Revolution. Crown Publishing Group, USA.
[4] Foreignpolicy. 2020. https://foreignpolicy.com/2020/05/14/china-us-pandemic-economy-tensions-trump-coronavirus-covid-new-cold-war-economics-the-great-decoupling/
[5] The Economist. 2019. https://www.economist.com/open-future/2019/06/28/globalisation-is-dead-and-we-need-to-invent-a-new-world-order

What can we expect from our relationship with our governments and companies? Under intense pressure, our traditional social contract is no longer working for a wide swath of individuals[6]. Societies have become divided between the haves and have nots, and any differences, whether religion, race, or sexual orientation, create chasms rather than common ground in the echo chamber of social media. As many experiences are digitalised, workforces, such as drivers, feel threatened by automation and do not feel valued or protected by either companies or the governments, as was more common in the past. As economies work to recover from COVID-19, discussions will continue regarding what should be included in the social contract between people, companies, and governments. It is likely that the changing nature of work and social contacts is going to have an impact on the use of space, particularly in cities where it has always been a precious commodity. While fears of an urban exodus may not come to pass, relentless urbanisation is also not necessarily a given and cities will need to adapt to new circumstances and innovations.
While these trends had already begun prior to the coronavirus pandemic, in many ways, they accelerated as the world fought to deal with the pandemic and now as we begin to build our post-COVID-19 world.

4.1.3. Work from home

Greater work from home (WFH) and flexible working was already an increasing trend before the crisis, but despite promotion by governments and authorities, was still limited to an extent: for example, before the crisis only 9 percent of the European workforce "sometimes" worked from home[7]. The confinement measures imposed to limit the severity of the health crisis may have led to the creation of new patterns and routines likely to endure. The generally positive experience of levels of productivity achieved during lockdown, facilitated by digital technology, has greatly increased the willingness of employers to promote WFH and flexible hours. This has also been driven by the wish to avoid staff travel during peak hours. Similarly, staff have realised the advantages of homeworking, such as more time with families and avoidance of costly and time-consuming commuting patterns. This is very likely, therefore, to become a major permanent trend. However, the limitations should also be recognised: many workers, such as blue-collar workers and essential service providers, are not able to WFH; and continuous WFH for long periods appears to be not sustainable due to adverse effects on health and morale, for example, burnout and feelings of isolation. A mix of WFH and working at the office therefore seems to be the most likely scenario for the longer-term future. For mobility planners, this means an overall reduction in demand (total km travelled) and, importantly, a flattening of the critical morning and evening peaks[8].

[6] Minouche Shafik, 2017, https://www.oecd-forum.org/posts/28677-rethinking-the-social-contract
[7] Eurostat, "How usual is it to work from home?", February 2020
[8] Arthur D. Little & UITP, The Future of Mobility post-COVID, 4th edition, 2020

4.1.4. Digitalisation

Digitalisation in the sphere of mobility has been advancing at pace, particularly in areas such as ticketing and payment (including tariff integration) and passenger information; deployment of MaaS (B2C and B2B) front-end application(s) allowing users to conveniently plan their multi-modal journeys, considering their preferences as well as prevailing circumstances; further digitalisation of operations reference.

The well-established digitalisation trend has been boosted by COVID-19, as businesses have sought to accommodate new ways of communicating, collaborating, and operating. Internet traffic increased by up to 30 percent during the crisis[9]. Within the mobility ecosystem the crisis is driving public transport operators to accelerate the digitalisation of their offerings (e.g., acceleration of the digitalisation of the customer interface for ticketing and payment, as well as of their passenger information channels), mainly to benefit the effectiveness of client interaction (i.e., reduction of physical touchpoints reducing the perceived risk of infections) and the personalisation of the client information (e.g., tailored messages considering client preferences). With travel being portrayed as an increased risk factor during the pandemic, the recovery strategy of many transport providers and authorities has been to use digitalisation as a way of facilitating seamless door-to-door travel. This reflects into a digitalisation trend which has also accelerated in areas outside of customer service, occurring for reasons of operational resilience – for example, flexibilization of planning, automation of cleaning[10].

4.1.5. Artificial intelligence

There is no universally accepted definition of 'artificial intelligence' because the meaning of 'intelligence' is arbitrary. Definitions of AI are debatable, and some are even "self-defeating"[11]. For instance, the World Economic Forum defines AI by its ability to "do things traditionally done by people", which makes the definition subject to change as technology progresses and takes up more tasks.

AI applications have been deployed in public transport to:

- Improve the quality and efficiency of tasks undertaken by employees.
- Reduce employee workload from mundane tasks to focus on more value-adding activities.
- Tackle specific problems, those that require solutions relying on complex analysis of data and predictions in dynamic, ever-changing environments.
- Provide efficient, safer, and cost-effective services to customer[12].

[9] The New Stack, "The Network Impact of the Global COVID-19 Pandemic", April 2020
[10] Arthur D. Little & UITP, The Future of Mobility post-COVID, 4th edition, 2020
[11] Antonio L. Elias, John D. Pararas, Potential use of artificial intelligence techniques in air traffic control, 1985
[12] UITP Asia-Pacific Centre for Transport Excellence, Artificial Intelligence (AI) in Mass Public Transport, 2020

4.1.6. E-commerce and demand for goods

Demand for last-mile delivery was already set to triple by 2050[13], but the COVID-19 pandemic has further accelerated a shift in goods mobility demand, driven by: closures of shops and restaurants and ongoing fear of infection; increased consumer appetite for home delivery acquired during lockdown (for example, there was an increase of more than 70 percent in France[14]); and increased availability of micro-delivery services (for example, ride-hailing solutions were diversified into goods delivery during the crisis). While overall demand for goods per person is likely to stabilise in the long and medium term following the initial shock from the pandemic, the way in which goods are being acquired and reaching their end users is likely to change in favour of more personalised options.

4.1.7. Sharing economy

In the context of mobility sector, biggest catalysers of disruption are platform economy and the complementary concept of shared economy. Platform economy can be defined as a medium which lets others connect to it[15] and shared economy is an economic system based on people sharing possessions and services, either for free or for payment, usually using the internet or more often a platform to organize it[16].
These two terms are closely interrelated as platform economy is an enabler of shared economy while using it at the same time. These economic models are enabled by the technological advancement of internet combined with democratisation of use and ownership of smartphones. The interconnection of these two is so strong that the European Commission (EC) uses the term "collaborative economy" and defines it as "business models where activities are facilitated by collaborative platforms that create an open marketplace for the temporary usage of goods or services often provided by private individuals"[17].

These trends are affecting societies in different ways; similarly, the way they interact with each other in impacting and affecting local contexts will differ greatly. In the context of mobility, they may sometimes act to increase the demand for travel, while having the opposite effect at other times. On the one hand, a reduction of working from the office may lead to fewer trips being taken, while on the other, additional time being spent not working might encourage individuals to spend more time outside their home, requiring a different type of mobility offer.
The seven trends presented here are by no means predictions of the future. They should be treated as contextual elements influencing the way by which some specific mobility solutions are

[13] Arthur D. Little and UITP, "The Future of Mobility 3.0 – Reinventing mobility in the era of disruption and creativity", March 2018
[14] Urbantz, "The Impact of the Coronavirus on Last Mile Delivery", 2020
[15] What is Platform Economy? Quora.
[16] Cambridge Dictionnary, Sharing economy.
[17] Communication from the European Commission, a European Agenda for the Collaborative economy.

being viewed, addressed and considered by potential end-users to meet their needs. The following chapter is going to provide more details into such solutions, looking at the level of technological maturity, its level of acceptance and possible threats users consider in relation to them.

5. END USER PERSPECTIVES AND MOBILITY NEEDS

5.1. Connected, cooperative and automated mobility

5.1.1. Connected and Automated Vehicles

Acceptance of technology

Acceptance of connected and automated vehicles seems to be evolving with time. The most recent 2020 Eurobarometer survey showed that 58% of the sample have heard, seen or read something about automated vehicles (AVs)[18].

AVs have been found to resonate more with men than woman, suggesting an important limitation in how the technology connects with gender identity[19].

The Deloitte global automotive consumer studies show that Generation Y/Z end users are generally more interested in fully autonomous vehicles[20].

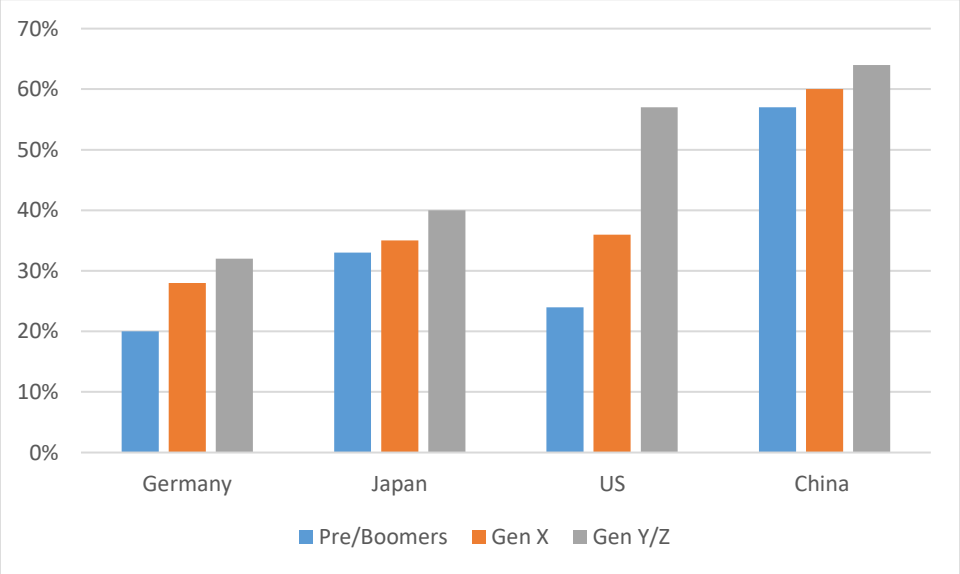

Figure 1: Consumer interest in fully autonomous vehicles, by generation

Benefits

[18] Special Eurobarometer 496 – Expectations and concerns of connected and automated driving, European Commission, 2020

[19] Spurlock et al., 2019. Describing the users: Understanding adoption of and interest in shared, electrified, and automated transportation in the San Francisco Bay Area. Transport. Res. Part D: Transport Environ

[20] What's ahead for fully autonomous driving, Deloitte, 2017

End user benefits include improved safety and reliability, as well as accessibility for those that are unable to drive conventional vehicles (e.g., people with disabilities)[21]. There are also potential positive attributes of time savings, time that can then be spent on other activities[22].
Risks and threats
Drawbacks of connected and automated vehicles for the end user include higher purchase price, potential for motion sickness, and threats to privacy and hacking of the vehicle. The widespread usage of AVs could also stimulate or exacerbate feelings of isolation and vulnerability, as well as loss of control and fear of technology[23].
Safety
The most recent 2020 Eurobarometer survey shows most respondents stated that they would not feel comfortable in a fully automated vehicle without the supervision of a human operator, but 70% of the respondents would feel comfortable traveling with the supervision of a human operator in it[24]. In a survey conducted by the Automobile Club Association of France, it was shown that consumers are in favour of autonomous vehicles, but they would like to have some safeguards in place. Most respondents understand autonomous vehicles within the traditional notion of driving: for instance, users of autonomous vehicles should be considered as drivers (51,2%) and have a driving licence (68%). In addition, 76,9% of respondents think passengers of an autonomous vehicle should designate a 'person in charge' that would intervene in case of deactivation of the autonomous mode[25].
Data privacy
Respondents in the 2020 Eurobarometer survey were asked how comfortable they would feel sharing their data with different agencies or other road users. Most respondents say they would not feel comfortable in sharing their data with any entity, but among these, public authorities (42%) are the entities with which respondents would feel most comfortable sharing data[26]. Survey results from the Automobile Club Association of France also confirm that consumers are highly concerned about the use of their data: while they accept that their autonomous vehicle collects data, consumers want to have a say on who should receive data and more than 80% of respondents are against an automatic transfer of data to the vehicle manufacturer[27].
COVID-19 impact
Due to rising health concerns and changing commuting patterns, demand amongst private consumers is also increasing for personal cars. According to Euromonitor's Voice of the Industry

[21] Jonn Axsen, Benjamin K. Sovacool., 2019. The roles of users in electric, shared and automated mobility transitions, Transportation Research Part D: Transport and Environment

[22] Pudāne et al., 2019. How Will automated vehicles shape users' daily activities? Insights from focus groups with commuters in the Netherlands. Transport. Res. Part D: Transport Environ.

[23] Jonn Axsen, Benjamin K. Sovacool., 2019. The roles of users in electric, shared and automated mobility transitions, Transportation Research Part D: Transport and Environment

[24] Special Eurobarometer 496 – Expectations and concerns of connected and automated driving, European Commission, 2020

[25] Consultation sur le véhicule autonome – La vision du consumateur, L'Automobile Club Association, 2020

[26] Special Eurobarometer 496 – Expectations and concerns of connected and automated driving, European Commission, 2020

[27] Consultation sur le véhicule autonome – La vision du consumateur, L'Automobile Club Association, 2020

survey, 13% of respondents indicated they plan to permanently increase usage of cars for their commuting. Moreover, COVID-19 has accelerated interest in getting a driving licence among the younger generation and city-dwellers. For example, automotive digital marketing company Hedges & Company projects total number of licensed drivers in the USA will increase by three million in 2020 to total of 230 million. Analysis of Google Analytics data also shows increased interest in driving tests in the USA, UK, Germany, Japan and other markets in the second half of 2020, indicating potentially growing demand for cars. In many cases new drivers are city-dwellers, and autonomous vehicles could be an attractive option for short-distance commuting. The autonomous cars eliminate the need to search for parking space and can be a more convenient option during the rush hours[28].

Public party expectations

According to the citizens debate conducted by Cerema end-users expect local authorities to participate in the development of AVs, in their role of economic and social players in the area. When the questions relate to changes in jobs affected by the arrival of AVs, 59% of their participants think that the priority of local authorities will be to see these changes in jobs coming: anticipate jobs that are about to disappear, provide training, career changes, etc. This role, already extant today, will have to be strengthened in the coming years to anticipate the increase in unemployment, greatly feared by participants, as soon as possible. “Local authorities must be the “pilots” for the deployment of autonomous vehicles," says one participant. Local authorities are therefore expected to organize the deployment of AVs within their area. The participants would also like local authorities to develop their role as purveyors of information: 51% of them think that local authorities should give the most objective information possible on this subject. This information and watchdog mission is to be seen in the context of the notion of trust that people have for local authorities. The current momentum emphasises the importance of transparency of information and decisions at all levels of the State and local authorities. Not surprisingly, even on this topic of AVs, people want access to clear and fully transparent information.

The development of DVs in Europe and internationally raises specific issues about harmonising regulations. How can we move from one country to another in an autonomous vehicle if the infrastructure has not developed in the same way, or if the technologies are not compatible? What if the Highway Code is completely different (driving on the right or on the left), or if one country is more advanced than others on this subject? Several AV experiments are being run in Europe (in Oxford, autonomous buses in Helsinki, the HEAT project in Hamburg, autonomous vessels in Amsterdam, etc.), but are rarely cross-border. Thinking and actions are under way at European level, but end-users have little knowledge of these at the present time[29].

5.1.2. Passenger urban air mobility

[28] https://blog.euromonitor.com/coronavirus-increases-demand-for-autonomous-vehicles/

[29] Cerema. Autonomous mobility and vehicles: what are citizens' expectations for tomorrow?. Bron : Cerema, 2019. "Connaissances" series. ISBN: 978-2-37180-376-3

Acceptance of technology

The concept of passenger urban air mobility is the extension of ground autonomous mobility to the third dimension: the skyscape. With the technological advances in batter, electrical power transmission, 5G and vertical take-off and landing aircraft infrastructure, urban air mobility could possibly deliver short-haul passenger air trips[30]. According to a recent preliminary study on acceptance for urban air mobility, most people surveyed are in favour of UAM deployment. 44% indicate they support, or strongly support, the initiative.[31] Nevertheless, issues on safety, noise, and other problems remain the main concerns for end users to adopt this technology. Figure 2 presents key findings of this survey.

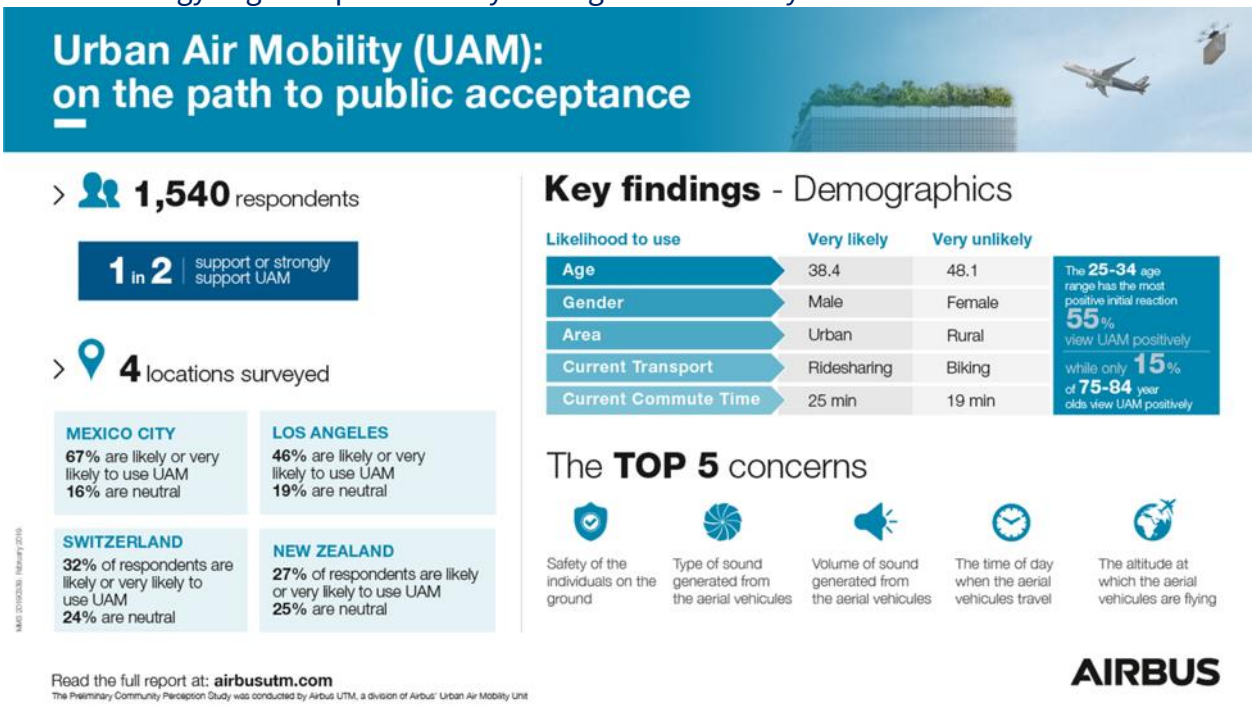

Figure 2: Airbus survey on public acceptance of urban air mobility

In addition, transport researchers have investigated factors that affect the adoption and use of urban air mobility[32]. Results show that safety and trust, affinity to automation, data concerns, social attitude, and socio-demographics are important factors for end users' adoption. Other factors including value of time savings, perception of automation costs and service reliability are also highly relevant to the acceptance of urban air mobility.

Benefits

[30] Thipphavong, D. P., Apaza, R., Barmore, B., Battiste, V., Burian, B., Dao, Q., ... & Verma, S. A. (2018). Urban air mobility airspace integration concepts and considerations. In 2018 Aviation Technology, Integration, and Operations Conference.

[31] Urban Air Mobility: on the path to public acceptance

[32] Al Haddad, C., Chaniotakis, E., Straubinger, A., Plötner, K., & Antoniou, C. (2020). Factors affecting the adoption and use of urban air mobility. Transportation research part A: policy and practice, 132, 696-712.

Urban air mobility has the power to link people to cities and regions. It can positively contribute to a multimodal mobility system, leading sustainable city development. Urban air mobility is expected to bring multiple benefits for different types of end users[33]:

1. Reduced need for vehicle traffic within urban core.
2. Reduced emergency response times.
3. Increased range of access to the urban core.
4. Urgency-trip pairing with commuter transit.
5. Stronger connection of rural areas to urban opportunities.
6. Increased utility of airport infrastructure.
7. Additional disaster response capabilities.
8. Elimination of transportation deserts.

Moreover, urban air mobility can also benefit business aviation users. It transforms short-range transportation for companies and individuals that use business aviation. Urban air mobility can solve the 'last mile' challenge by moving business passengers quickly from a company office to meetings in city centres that are near to existing heliports[34].

Risks and threats

The main risks of threats of end users' acceptance of urban air mobility are briefly mentioned in previous section, including operation safety, type, and volume of noise that the technology creates during operation and individual privacy for the end users. If the current technologies could not minimize these risks, it might threaten end users and residents who live in the regular route of urban air mobility services[35].

Safety

Urban air mobility will create operational issues and safety concerns because of its uncertainties and scale of influences in urban areas, especially in the early transition period when these aircraft are expected to be manned by pilots and assisted by onboard automation systems[36]. During this transition period, the type of flight control used during take-off and landing will often be different from the type of control used on the way. Although electric vertical take-off and landing have greater levels of automation, it entails greater variability in the type and scope of human control. Therefore, safety is still the main concern in the implementation of urban air mobility.

Environment and sustainability

Although urban air mobility might achieve targets of sustainability and decarbonization, it might create noise and visual pollution, which will impede the sustainable and thus successful introduction of this innovation to cities[37]. In the future, it is essential to 1) establish regulations for air traveling at low altitudes in urban areas, especially in what concerns air traffic management to ensure flight safety, 2) devise an efficient, reliable and light all-electric or

[33] Community Benefits of Urban Air Mobility

[34] New Report Explores the Benefits of Urban Air Mobility for Business Aviation

[35] Understanding Risk in Urban Air Mobility: Moving Towards Safe Operating Standards

[36] Bauranov, A., & Rakas, J. (2019, September). Urban air mobility and manned eVTOLs: safety implications. In 2019 IEEE/AIAA 38th Digital Avionics Systems Conference (DASC) (pp. 1-8). IEEE.

[37] Eißfeldt, H. (2020). Sustainable Urban Air Mobility supported with participatory noise sensing. Sustainability, 12(8), 3320.

hybrid-electric propulsive system (from the energy source up to the propeller/rotor) that can power these aircraft, and 3) design an aircraft that can comply with noise regulations for operating in urban areas[38].
Data privacy
Data is the key for implementation of urban air mobility. It is important to ensure data sharing and data privacy simultaneously. The operators must be aware of cybersecurity issue as the risk associated with hacking passenger air mobility is high. If a third party takes control of the vehicle or infrastructure, it will cause a major collision or other security threat. In addition, the leak of end users' personal information or facial recognition might also threat to end users (e.g., banking).
COVID-19 impact
COVID-19 has slowed down the collaborative endeavour of urban air mobility, where co-location has been one of the key drivers of technological innovation. Indeed, Uber Air disclosed that remote working has impacted the ability of their vehicle partners to conduct research and development activities[39]. In addition, COVID-19 decreases the opportunities for relationship building, which is key to building trust to get the first pilots and commercial services off the ground. Recently, Airbus' urban air mobility operations company, Voom app-based helicopter booking platform, has ceased its operation on March 2020, citing the COVID-19 pandemic as its cause of death[40].

5.1.3. Drone last mile delivery

Acceptance of technology
From retail deliveries at rush hour to scanning hard-to-reach places, drone features are proving to be extremely beneficial in places where man cannot reach or is unable to perform in a timely and efficient manner. Individual consumers, commercial entities, and governments have come to realize that drones have multiple useful features, which include[41]: 1. Express shipping and delivery. 2. Gathering information or supplying essentials for disaster management. 3. Thermal sensor drones for search and rescue operations. 4. Geographic mapping of inaccessible terrain and locations. 5. Building safety inspections. 6. Precision crop monitoring. 7. Unmanned cargo transport. 8. Law enforcement and border control surveillance. 9. Storm tracking and forecasting hurricanes and tornadoes.

[38] Afonso, F., Ferreira, A., Ribeiro, I., Lau, F., & Suleman, A. (2021). On the design of environmentally sustainable aircraft for urban air mobility. Transportation Research Part D: Transport and Environment, 91, 102688.

[39] The impact of COVID-19 on the eVTOL industry

[40] Voom Ceases Operations (Mostly) Due to COVID-19, Airbus Declares Victory

[41] Drone technology uses and applications for commercial, industrial and military drones in 2021 and the future

Drones are still in the early stage of mass adoption and usage, but they have already broken through rigid traditional barriers in industries. A recent study on public acceptance of drone applications suggest that "acceptance levels towards drones did significantly differ depending on the context of use. Industrial areas had the highest acceptance level, followed by recreational areas and commercial areas while residential areas had the lowest acceptance level"[42]. Different context will lead to different acceptance level. Another study shows that drones were not well accepted at present because of public safety issues. Commercial (e.g., last mile delivery) and hobby uses are especially not supported by public. Public sees the drones as a risky technology that directly interferes with their privacy[43].
Benefits
Drones possess the capability of reaching the most remote areas with little to no manpower needed and require the least amount of effort, time, and energy. This is one of the biggest reasons why they are being adopted worldwide. Since drones use Global Positioning System (GPS), they can be programmed and maneuvered accurately to precise locations[44]. This is especially helpful in a variety of situations such as last mile delivery, precision agriculture and rescue. The precision of drones can avoid the risks of delay and enhanced end users' experience. Indeed, drones allows deliveries to avoid traffic and complex navigation paths. The speed of drones is a major selling point for end users.
Safety
For the drone last mile delivery, individual safety is a primary concern. To avoid mid-air collisions, drones must be programmed with "sense and avoid" capabilities that match those of manned aircraft. This means that drones must be able to detect a potential collision and manoeuvre to safety. In the event of system failures, falling drones are another danger. In addition, the camera on a drone is another concern because it might hamper individual privacy if data was used in another purpose. Drones can collect data and images without drawing attention of audiences, which makes end users fear to use this new technology.
Environment and sustainability
Faster delivery times could potentially reduce shipping costs for end users, and this, in turn, may result in a sales boost for retailers. In the meantime, drones can help tackle climate change by reducing energy consumption as well as the release of greenhouse gases.
COVID-19 impact
COVID-19 has fostered the application of drones in three areas. First, drones were used to pick up samples from potential patients and transport relevant medical supplies to minimise the spread of infection and decrease the transportation time for goods delivery. Second, some countries (e.g., China, UAE, Spain, and South Korea) have used drones to spray public areas to disinfect potentially contaminated places. Third, some governments (e.g., China, Spain and Italy) have used drones to monitor and guide public space during lockdown and quarantine. The video surveillance and broadcasting of voice with a drone might reduce the possibility of

[42] Tan, L. K. L., Lim, B. C., Park, G., Low, K. H., & Yeo, V. C. S. (2021). Public acceptance of drone applications in a highly urbanized environment. Technology in Society, 64, 101462.

[43] Aydin, B. (2019). Public acceptance of drones: Knowledge, attitudes, and practice. *Technology in society*, *59*, 101180.

[44] The Pros and Cons of Drones and Unmanned Aerial Vehicles (UAVs)

direct contact with potentially infected people. These increases the popularity of drones, which might make the application of drone last mile delivery more acceptable.

5.2. Infrastructure, network and traffic management

5.2.1. Big data for mobility

Acceptance of technology
The acceptance of using big data in transport stems primarily from the following factors: a) availability of vast amounts of electronic data[45], b) the limitations of existing methods used for planning, control, and evaluation in the transport sector[46], and c) the large range of areas where big data analytics can find an application in transport sector[47]
Benefits
Big data technologies can positively impact different aspects of the transport sector. These aspects have been discussed in detail in the H2020 projects LeMO and NOESIS. From the end user's perspective this would mean an improvement in[48]: • *Service performance* – where services become more efficient, inclusive and user oriented, reducing waiting and travel times of commuters, including those who are challenged and vulnerable. • *Environment* – where big data technologies help in addressing the impact of transport on environment through decarbonization; transport electrification; noise and vibration reduction; resource consumption; and environmental monitoring. • *Safety and Security* – where big data helps in building resilience of transport infrastructure to natural disasters; in identifying unsafe transit points; in enforcement of rules relating to rest and recuperation of drivers; in preventing acts such as transport of illicit goods and theft through improved surveillance; in better vehicle safety design. • *Transport Network Capacity* – where big data can support long term transport planning and real-time traffic management to reduce congestion and mitigate risks that degrade network capacity.
Risks and threats
The use of big data technologies in transport sector also involves several risks and threats, which can be legal, ethical, social or economic. Key risks are listed below[49]:

45 https://lemo-h2020.eu/newsroom/2018/5/13/deliverable-11-understanding-big-data-in-transport-sector
46 Ibid.
47 NOESIS-H2020/Deliverable 2.2 Big Data implementation context in transport
48 https://lemo-h2020.eu/newsroom/2020/6/30/first-version-of-the-lemo-research-and-policy-roadmap-is-published
49 For a more detailed discussion of different threats and risks see - https://lemo-h2020.eu/newsroom/2019/10/1/new-report-published-identification-and-characterisation-of-barriers-and-limitations

- *Privacy /Surveillance/Free will/Data Protection* – One of the biggest concerns regarding the use of big data in transport relates to privacy, as transport data can reveal quiet an intrusive description of people's lives. Mere technical data, due to transformational impact of big data analytics, can be converted into personal/sensitive data. This also gives rise to concerns about surveillance both at individual and population level. Another related problem arises in terms of 'free will', where it is believed that 'predictive analytics' can make surveillance into an active tool to shape the behaviour of people, thus impacting their free will. On the other hand, generic data protection laws, can completely stifle the use of big data technologies, preventing societies to benefit from the positive potential of such technologies.
- *Security* – big data applications are more lucrative target for threat actors, as they are a rich source of data and even minor breaches can reveal huge amounts of information. The complexity and scale of systems, as well as heterogeneity in the protection measures across different EU member states, further add to the vulnerability of big data applications.
- *Data Ownership/Control* – There is no specific ownership right in data and many commercial stakeholders claim ownership in datasets based on contractual agreements, leaving the end-user without a sense of control over their data.
- *Liability* – Since ownership in datasets is claimed based on contractual agreements, many stakeholders try to limit, disclaim, exonerate their liability or transfer it onto the other party, unfairly impacting the end-users. A lack of harmonized legal framework at the EU level also adds to this concern.
- *Social Exclusion/discrimination/bias* – Use of big data in transport sector also gives rise to concerns related to discriminatory exclusion as big data analytics can be vulnerable to technical and systemic biases. It is believed that such biases can arise on account of data heterogeneity, size of data sets, data quality, noise accumulation, spurious correlation, incidental endogeneity, and algorithms complexity.
- *Environment degradation due to rebound effects* – The use of ICT infrastructures to process big data applications can lead to greater energy consumption thus creating a rebound effect where the disadvantages of using such applications outweigh the advantages with respect to the environment.
- *Risks to businesses due to data quality, dark data and data silos* – Since use of big data in transport is still in its early days, businesses using big data applications to offer new mobility services to their clients run the risk financial and reputational damage. This can happen due to different reasons. For example, a business may end up producing a bad product for their clients due to bad quality of data. Or it may suffer reputational damage due to breach of sensitive data of its clients, which the business may have accumulated unknowingly (dark data). A business may also not be able to maximise the use of data, due to silos created by incompatible technologies in its organization or lack of awareness about availability of certain datasets.
- *Technocratic transport* – Extreme reliance on big data in the transport sector can increase the risk of algorithmic governance of transport, leading to the exclusion of different stakeholders as well as vulnerable and marginal groups.

Safety

Safe use of big data technologies in transport entails tackling the negative externalities (i.e., risks and threats listed above) and maximising the benefits that big data analytics can offer to the transport sector. In this context, generating "trust" in the use of big data technologies is crucial. It has been observed that "trust" in this technology can be easily lost by the end-users on account of errors and heterogenous values generated by low quality of data or the presence of redundant, old and un-updated data. Similarly, trust can also be lost due to people acting against a moral requirement. A lack of trust can quickly pollute the perception of safety of big data technologies in the transport domain.

Environment and sustainability

The use of big data in transport industry can lead to a positive impact on the environment and sustainability. It can increase energy savings (through optimization of transport routes and consequent fuel savings), it can reduce GHG emissions (by facilitating transition to use of renewable energies) and it can help decrease other environmental pollutants (through optimizations made during vehicle production phase).

However, experts warn that "rebound effects" (an increase in usage that cancels out a portion of the expected societal benefits) may cancel out these positive impacts should be considered and addressed to gain the maximum benefit from big data technologies in the transport domain.

It is considered that such rebound effects may arise *firstly* on account of increased energy consumption by the ICT infrastructure used to deploy big data technology in the transport sector and *secondly* because of behavioural changes prompted by big data technology, which may be equally or even more unhealthy (e.g., a re-routing suggested to avoid traffic jams causes cars to take a longer route or pass-through residential areas)[50].

Data privacy

As mentioned before, concern about data privacy is one of the biggest risks related to the use of big data technologies in the transport domain. Mere technical data, due to the transformational impact of big data analytics, can be converted into personal/sensitive data. This also gives rise to concerns about surveillance both at individual and population level. Another related problem arises in terms of 'free will', where it is believed that 'predictive analytics' can make surveillance into an active tool to shape the behaviour of people, thus impacting their free will. On the other hand, generic data protection laws, can completely stifle the use of big data technologies, preventing societies to benefit from the positive potential of such technologies. In this context, a proactive approach is required to address the privacy concerns requiring interventions both at research and policy level.

At research level, it is suggested that robust data protection methods should be developed that allow for adequate value extraction from data without compromising privacy and security. To this end, experts advise the development of methods that quantify privacy loss and data utility need to be developed and dynamic deployment of various data protection techniques, considering the situation, utility, type of data involved[51].

[52]

50 For a more detailed discussion on rebound effects see https://lemo-h2020.eu/newsroom/2018/11/25/deliverable-24-on-trade-off-from-the-use-of-big-data-in-transport

51 https://lemo-h2020.eu/newsroom/2020/10/30/lemo-research-and-policy-roadmap-is-published

At policy level, it is suggested that there is a need to increase competence and awareness about data protection techniques in transport sector. As it will not only increase data privacy but also build trust by end-users[53].
COVID-19 impact
Some experts believe that COVID-19 can accelerate the uptake of new technologies in the transport sector. With respect to big data, it has been observed that COVID-19 offers opportunities to collect new types of datasets (such as last mile delivery data, due to a surge in e-commerce)[54] and can be used to ensure safety during use of public transport[55].

5.3. MaaS and MaaS Platform

Acceptance of technology
Based on a sample conducted by the MaaS4EU project, 76.2% of end users were familiar with the concept of MaaS. The level of confidence in smartphone use will have an impact on the acceptance of MaaS. Generation Z and X users are more likely to be confident using MaaS apps rather than the Silent Generation or Baby Boomers. MaaS is also likely to appeal most to infrequent car users and least to frequent car users[56].
Benefits
Convenience and flexibility are the most significant benefit of MaaS for end users according to the MaaS4EU project. From the end user perspective, MaaS provides personalised and smart mobility services that reflect diverse needs. Seamless, transport services function well and provide easy access to mobility, strong user orientation, high-quality services, and competitive pricing. By removing friction and offering choice in facilitating end-to-end journeys, MaaS encourages travellers to pursue other methods of transport than the private car, presenting a cost-conscious transportation alternative.
Risks and threats
A lack of secure payment options, real-time information, reliable service or inclusion of all transport means of the city can be seen as risks for a successful end user MaaS experience.
Safety
What can a customer expect on physical safety and security of services according to the MaaS Alliance[57]: • In case of accident, the user is protected by MaaS Operator or for instance by insurance company, covering the whole journey.

53 Ibid.

54 https://www.exlservice.com/covid-19-and-big-data-fresh-insights-for-the-trucking-industry

55 See e.g. https://www.intelligenttransport.com/transport-news/102985/dubais-rta-uses-big-data-to-monitor-physical-distancing-on-buses/ and https://www.intelligenttransport.com/transport-articles/111970/predicting-public-transport-occupancy-with-big-data-steven-ahlig-tells-all/

56 Whittle, C., Whitmarsh, L., Hagger, P., Morgan, P., & Parkhurst, G. (2019). User decision-making in transitions to electrified, autonomous, shared or reduced mobility. Transportation Research Part D: Transport and Environment, 71, 302-319. https://doi.org/10.1016/j.trd.2018.12.014

57 MaaS Alliance, 2019. Recommendations on a User-Centric Approach for MaaS

- In case of accident or misbehaviour, clear means to get appropriate response throughout the system.
- Collaboration with operator and public sector to enhance the safety of the users.
- Possibility to evaluate the safety of each component of the journey through the application. The feedback from the users will be shared with respective actors and used to improve safety and security of the system.

Environment and sustainability

In 2018, Transport for Greater Manchester (TfGM) and Atkins/SNC-Lavalin tested the hypothesis that MaaS could shift commuters out of their cars, either onto public transport or towards active travel options such as walking and cycling to work. This work took a very customer-centric and human-centred approach from the outset.

39 participants from across the city, and all working in Salford, took part in the live trial. Immersive research captured rich data from the participants, including in-depth interviews and ridealongs with passengers, which provided insights into the key day-to-day issues affecting commuters. Seven modes of travel were offered in the personalised journey plans: buses, trams, carshare, taxi, bike share, on-demand shared mini-bus and walking.

Extensive analysis showed that MaaS could be a significant tool in achieving TfGM's objectives, as 26% of participants were more willing to use public transport, and 21% were more willing to cycle and walk. This indicates that MaaS has the potential to create more sustainable travel behaviours (active travel modes and ride-sharing), which can help address the challenges local authorities face in urban areas. Six months following the trial, 82% of participants interviewed wanted MaaS back. One third of car owners wanted to give up their vehicle following the research, and most participants were willing to pay an increase in their monthly travel expenses for MaaS[58].

Data privacy

What can a customer expect on digital safety and security of services according to the MaaS Alliance[59]:

- All processing of personal data needs to be done in accordance with the General Data Protection Regulation, this also includes the identification of the correct legal basis.
- Information addressed to the data subjects should be concise, easily accessible, and easy to understand.
- Anonymous trips should be an option where possible.
- Anonymised and/or aggregated data produced in MaaS ecosystem should be made available for the purposes of, including but not limited to, traffic management, traffic planning and urban planning, whilst respecting commercial interests of parties involved.

Private party expectations

Based on a sample conducted by the MaaS4EU project, most of the respondents would like to receive alerts when there are problems with their selected route, while the provision of route recommendations are important to them. Most of them would like to view routes that are tailored to their current context (e.g., weather conditions, time of year) and their preferences. Furthermore, they would like to get recommendations to switch to another available plan that

[58] UITP – International Association of Public Transport, 2019. Report Mobility as a Service

[59] MaaS Alliance, 2019. Recommendations on a User-Centric Approach for MaaS

fits better to their needs. On the other hand, they would not like to be part of a social network of users that have subscribed to a MaaS package.

5.4. Shared and on demand mobility

Acceptance of technology
Literature supports that younger generations are more open to sharing services, while elderly people are more loyal to their current means of transport. One proposed reason for this is a change in the association between car ownership and status; this has been weakened, specifically amongst children and young adults. People owning a university degree are more open to sharing services and the same applies to those with higher income. People living in bigger cities are more willing to use sharing services and the same applies to people owning more than a car60. Car-sharing appeals to social and environmental activists and innovators as well as those more financially or pragmatically motivated, and is popular amongst women, students and bus users[61].
Benefits
Benefits for end-user's include lower or more predictable costs, simplicity, compatibility with lifestyle, the allowance of more travel options, and the avoidance of risks associated with vehicle ownership[62].
Risks and threats
Risks and threats of end-user's uptake to shared and on demand mobility includes inconvenience, difficult access to the mode, or feeling dependent on the reliability of other people using the service properly (e.g., returning the vehicle on time). Furthermore, a perceived risk of being 'contaminated' by previous users and a concern for being responsible for looking after something that one does not own also act as barriers to using shared services[63].
Safety
Personal safety with respect to accidents is an important concern for end-users with shared mobility. This is reflected within the use of bicycle sharing in Malta. Road safety is a common barrier, which negatively affects the willingness to consider the use of bicycles. To encourage the use of shared bicycles, and cycling as a mode of transport in general, survey respondents clearly

[60] Curtale, R., & Liao, F. (2020). User acceptance and preferences of sharing mobility services.

[61] Whittle, C., Whitmarsh, L., Hagger, P., Morgan, P., & Parkhurst, G. (2019). User decision-making in transitions to electrified, autonomous, shared or reduced mobility. Transportation Research Part D: Transport and Environment, 71, 302-319. https://doi.org/10.1016/j.trd.2018.12.014

[62] Jonn Axsen, Benjamin K. Sovacool, The roles of users in electric, shared and automated mobility transitions, Transportation Research Part D: Transport and Environment, Volume 71, 2019, Pages 1-21, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2019.02.012.

[63] Whittle, C., Whitmarsh, L., Hagger, P., Morgan, P., & Parkhurst, G. (2019). User decision-making in transitions to electrified, autonomous, shared or reduced mobility. Transportation Research Part D: Transport and Environment, 71, 302-319. https://doi.org/10.1016/j.trd.2018.12.014

indicate the need for safer conditions for cycling, through the creation of dedicated infrastructure and awareness raising about road safety for all road users[64].
Environment and sustainability
With the potential for reductions in cost, time use, and environmental and energy impacts in shared and on demand mobility comes the potential for rebound effects. Within ride-hailing, reductions in travel costs and travel times can lead to increased societal impacts through the subsequent switching away from public transport, driving longer distances and relocating of residences further from the urban centre. Their simulation of travel and land-use behaviour find that such effects can cancel out two-thirds (or more) of GHG reduction benefits and more than half of societal benefits in aggregate.
COVID-19 impact
End-users seem to perceive sharing services as safer against COVID-19 contagion compared to public transport. For most people, it seems that medium or long-term mobility choices are not affected by COVID-19[65].

[64] Suzanne Maas, Maria Attard, Attitudes and perceptions towards shared mobility services: Repeated cross-sectional results from a survey among the Maltese population, Transportation Research Procedia, Volume 45, 2020, Pages 955-962, ISSN 2352-1465, https://doi.org/10.1016/j.trpro.2020.02.071.

[65] Curtale, R., & Liao, F. (2020). User acceptance and preferences of sharing mobility services.

6. CONCLUSIONS

This report contains trends of disruptive innovation and a review of end user perspectives and mobility needs. Within GECKO new mobility solutions end-users include passengers, members of shared services, drivers, and owners, as well as other stakeholders such as pedestrians, cyclists, planners, and policymakers.

As socio-economic trends this report discusses the “decoupling" of economies, rethinking the social contract, work from home, digitalisation, artificial intelligence, e-commerce and demand for goods, and the sharing economy.

In the case studies it is seen that generally the new mobility solutions are accepted. An exception can however be seen with drone last mile delivery as the technology is perceived as risky in residential areas and interfering with privacy. Overall a higher acceptance of new mobility solutions is registered with men rather than woman, and with Generation Y/Z rather than older generations.

The end-user benefits for the new mobility solutions include safety, reliability, accessibility inclusiveness for people with disabilities, speed, time savings, reaching remote areas, user oriented, convenience, flexibility, predictable costs, simplicity, compatibility with lifestyle, more travel options, and the avoidance of risks associated with vehicle ownership.

As risks and threats the end-user perceives safety as a key issue. This is witnessed in passenger urban air mobility and drone last mile delivery. To improve safety for end users the following measures can be implemented, maintaining trust with end users will uphold the perception of safety in the service and the supervision of a human operator in automated vehicles. For bike sharing safer conditions are needed for cycling in general, through dedicated infrastructure and awareness raising about road safety for all road users. For drone last mile delivery, “sense and avoid” capabilities that match those of manned aircraft are needed to avoid mid-air collisions. Other risks and threats to the take-up by end users include purchase price, potential for motion sickness, threats to privacy, hacking of the vehicle, noise, inconvenience, difficult access to the mode, feeling dependent on the reliability of other people using the service properly and contamination.

New mobility solutions have the potential to create more sustainable travel behaviours, reduce environmental, GHG and energy impacts. However, there is also the possibility for rebound effects that can increase usage that cancels out a portion of the expected societal benefits. This can be observed in big data for mobility and ride-hailing. End users are highly concerned about the use of their data and do not feel comfortable sharing is with other entities.

The mobility behaviours of end-user’s have changed in response to COVID-19. This is largely due to government restrictions, changes in working conditions, and people’s concern about health-

socio-economic consequences of COVID-19. The pandemic has in some cases accelerate the uptake of new technologies in the transport sector. Examples are provided by the case studies connected and automated vehicles and drone last mile delivery. COVID-19 has however also slowed down the collaborative endeavour of innovations, such as with passenger urban air mobility.

End users expect from public parties to participate and organize the development of new mobility solutions within their area, anticipate changes new mobility solutions can bring to the labour market and act as purveyors of information. From private parties they expect to receive tailored services and recommendations related to costs of the service.

GECKO CONSORTIUM

The consortium of GECKO consists of 9 partners with multidisciplinary and complementary competencies. This includes leading universities, networks and industry sector specialists.

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