



#BetterMobility

The Future of Mobility post-COVID

*Turning the crisis into an opportunity to accelerate
towards more sustainable, resilient and human-centric
urban mobility systems*

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Figure 1: Overview of organizations that were consulted for this study



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Foreword

As we write this report in July 2020, large parts of the world are emerging from lockdown and slowly restarting the economy. City centers which have been eerily deserted are starting to show signs of life, but even with offices, restaurants and shops reopening, it is obvious that things are far from being “back to normal”. How long the recovery will take, what the new normal will look like, and what this means for our mobility systems remains unclear. However, governments, transport authorities and mobility providers still need to prepare now for this uncertain future. With this in mind, Arthur D. Little, together with our long-term partner, UITP – the International Association of Public Transport – has conducted a study engaging with over 70 executives from 30 organizations (transport authorities, mobility solutions providers - public transport operators and “new mobility” solutions providers - and professional bodies) across the world to understand better how mobility could evolve in the post-COVID world, and in particular, to identify new opportunities that are arising from the disruption caused by the crisis, despite its terrible impact on so many people.

This special Future of Mobility report is the fourth in a series: the first global Future of Urban Mobility study, published in 2011, highlighted the mobility challenges cities faced on a worldwide basis and saw the release of the first edition of Arthur D. Little’s Urban Mobility Index, which assessed mobility maturity and performance of mobility systems worldwide. The second edition of the study, published in 2014, threw further light on what was holding cities back and identified three strategic paths for cities to pursue, as well as 25 strategic imperatives to consider when defining sustainable urban mobility policies. The third edition, published in 2018, examined societal and technology trends, as well as new mobility solutions, reflected on their likely impact on future mobility ecosystems and provided 12 strategic imperatives for mobility solution providers to consider when defining their visions and strategies to remain competitive in the short term and relevant in the long term.

In this fourth report we assess the likely impact of COVID-19 on future mobility patterns and provide a valuable summary of more than 100 actions that transport authorities and mobility solutions providers are taking, or planning to take, in response to the crisis. We also identified six “game changers” that we believe are critical for mobility system players to make the most of what we believe is a unique window of opportunity to move towards more sustainable, resilient and human-centric mobility systems. We hope you enjoy reading the report, and that it will be informative for your further mobility endeavors.

Sincerely

Francois-Joseph van Audenhove
Partner, Arthur D. Little
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Executive summary

It is clear to all that mobility systems have been drastically affected by the COVID-19 pandemic. As a result of lockdowns, social distancing and hygiene requirements, demand for personal mobility has plummeted, while operational complexity has increased. At the same time, demand for e-commerce and home delivery has exploded. As we write, many cities are gradually reopening after lockdown, but the duration and trajectory of the recovery is still uncertain. As well as a major economic downturn, most observers agree that at least some of the changes in behaviors we have seen during the crisis will endure in the medium- to long-term. The post-COVID world is unlikely to look exactly the same.

Organizations within the mobility system need to develop strategies that will help to shape the future, provide options to respond to different outcomes and offer insurances in case of unforeseen setbacks. To do this, they need to answer some key questions: what are the likely impacts of COVID-19 on mobility patterns in the medium- to long-term? What should be the most appropriate strategic responses for mobility policy makers and service providers in the post-COVID world? In particular, what opportunities are there to leverage the disruption caused by COVID-19 to make a step change towards the goal of more sustainable, resilient and human-centric mobility systems?

To shed some light on these questions, Arthur D. Little, in collaboration with the UITP, initiated the “Future of Mobility post-COVID” study. From May to July 2020, we engaged with over 70 leaders and top executives from over 30 organizations across the world, covering transport authorities, mass transit operators, “new mobility” solutions providers and professional bodies, to exchange views on the impact of the crisis, actual and planned responses, and insights on the longer-term future. We are very grateful for their excellent contributions. This report provides the results of the study.

Mobility patterns in the post-COVID world

In order to establish a view on how the crisis will affect future mobility patterns and behaviors, we assessed its impact on existing key mobility trends. We identified 12 trends that would be affected across three categories – global, behavioral and technology/market:

- **Global:** Passenger demand growth; socio-economic inequality; e-commerce; city topology transformation.

- **Behavioral:** Working from home/flexible working; travel-safety consciousness; healthier mobility lifestyle; re-spacing and retiming of trip patterns.
- **Technology/market:** Digitalization of offerings; acceptance of new forms of mobility as part of the system; market consolidation of private mobility players; intelligent transport systems.

The striking result is that with the exception of passenger demand growth (measured in passenger-km) which is expected to slightly decelerate in the coming years, all the other trends will be likely to be accelerated by the crisis, which, in itself, opens up opportunities to drive change, provided that policy makers and public transport operators and “new mobility” MSPs are able to seize the opportunity. Our study respondents believed that, while it was important not to be caught up in the hype and fear surrounding post-COVID predictions, at the same time it should not be assumed that impacts would be limited.

Opportunities to shape more sustainable, resilient and human-centric urban mobility systems

Diseases shape cities. While the crisis has had, and will continue to have, tragic consequences for many people, it has also led to new conditions which can be leveraged to drive innovation towards more sustainable, resilient and human-centric urban mobility systems. COVID-19 was, for everyone, a “life-changing moment,” and it is easier to change behaviors during such moments; city centers with less car traffic can be more easily used as “sandboxes” for innovation; there is increased public awareness of environmental and health benefits; and rapid actions taken during the crisis by authorities and operators have demonstrated the “art of the possible” in terms of rapid and agile decision-making.

Among the key players that can have the greatest impact are the city governments and transport authorities. For those authorities that are committed to effecting significant change, two broad types of action can be undertaken: Framing (regulating the mobility system and its components) and Enabling (enabling other mobility system actors). Many of the authorities we engaged with in this study have already been taking new framing and enabling actions during the crisis. We have included in the main report some 40 examples of these actions which we believe provide a valuable overview, for example:

- **Framing:** Urban space reallocation; transversal mobility mode planning; “new mobility” reregulation; contract reengineering with private mass transport providers; parking and curb management; new data regulation; and new enforcement measures.
- **Enabling:** New governance arrangements for better collaboration across the system; reassessment of investments in mobility infrastructure (e.g., favoring reversible, lower-cost, healthier mobility modes); accelerated investment in digital infrastructure for Mobility-as-a-Service (MaaS); new mobility demand management measures (e.g., promoting e-bikes/scooters, shared mobility, peak flattening); and collaborative innovation platforms.

Not all authorities are equal in their ability and willingness to shape a change of paradigm in the aftermath of the crisis. We found that a minority were “Non-believers” not recognizing any urgency to radically rethink the system, a few more authorities were “Progressives” already committed to the need for change, and the remaining 50 percent were “Stuck in the middle,” recognizing the need but struggling to make it happen. Three key obstacles were identified: lack of proven ability to be visionary; unclear accountabilities between government and the transport authority; and lack of personal leadership. While it is evident that size and available resources limit the type of actions that can be undertaken, ultimately this is not the determining factor and should not be used as an excuse for lack of action. There is a shared fear that unless changes are made, the majority of authorities, maybe as many as two-thirds, may not be in a position to do what is necessary to drive the required change.

Overall, we identified three game changers for city governments and authorities to frame and enable mobility systems for the post-COVID world:

- **Game changer #1 Think and act at system level: Develop a unified long-term mobility vision;** implement system-level regulation; adopt system-level execution planning; and revise the mobility-funding equation.
- **Game changer #2 Foster innovation through public-private collaborations on innovative technology and business model development:** Collaborate on technology development and implementation; collaborate on innovative business models; and promote innovation schemes, competitions and projects.
- **Game changer #3 Set up a Unified Mobility Management Model, enabling real-time optimization of mobility flows and assets at city or national level, including:** a unified long-term mobility vision; a master mobility data lake; standards and protocols for data collection and bidirectional data exchange; a public authority back-end powered by algorithms; a multi-actor governance approach; and a Unified

Mobility Management Model beyond MaaS to enable real-time optimization of flows and assets.

How MaaS and a Unified Mobility Management Model could contribute in the post-COVID world

The concept of MaaS has been subject to hype over recent years. In the short term, the COVID-19 crisis is likely to have a negative impact on the scalability of MaaS development, as the MaaS business model largely revolves around trips performed with mass transit and shared mobility modes which have suffered from collapsing demand. In the medium term, MaaS can contribute to increased system resilience through providing more choice of mobility options and ease of use. Trust can also be rebuilt by providing real-time multimodal information. However, the current low level of deployment and adoption of MaaS in cities worldwide heavily limits possible impact in the medium term. In the longer term, MaaS certainly has the potential to positively influence mobility patterns and behaviors in a way that will align much better with the uncertain post-COVID environment. The development of MaaS business (B2B) offerings could be an accelerator for further penetration, as the openness of companies to adopt flexible working hours and engage with transit operators has been increased as a result of COVID-19.

Data is the key for a unified management model to enable MaaS. In the main report (Chapter 4), we have set out the components of a robust, secure and transparent data infrastructure and Unified Mobility Management Model that would be required to handle in real-time all mobility-related data, whether generated by moving or fixed parts of the mobility system, privately- or publicly owned/operated, and shared or unshared. The model needs to have in place standards and protocols to enable data exchange, a middle layer to ensure real-time provision of services and management with empowerment of all actors, and the MaaS/TaaS¹ front ends to orchestrate different mobility services to deliver a seamless experience to users. We believe that this Unified Mobility Management Model, although challenging to achieve, promises to solve most of the mobility issues we face in the post-COVID world.

Opportunities to evolve offerings and operating models for increased resilience

Mobility solution providers have faced collapsing demand with increased operating costs during the crisis. Looking forward, profitability will continue to be challenged by reduced patronage affecting both farebox revenues and ancillary revenues from advertising, retail and property development. As well as seeking essential short-term cost reductions and improvements to staff and asset productivity, mobility solutions providers now need to consider more pivotal and fundamental adaptations that can

¹ Referring to Transport-as-a-Service applicable to goods mobility

be made to their offerings and operating models. Adaptation of commercial offerings by PTOs and MSPs during and in the aftermath of the crisis is, in general, driven by two objectives:

- Improving the overall **customer experience** to support regaining trust, and to drive customer stickiness, preference and loyalty.
- Improving the **resilience** of the offering in the context of possible rapid fluctuations in demand in the future, in case of future crises.

In the main report we have provided some 70 examples of either new or accelerated actions being taken by PTOs and MSPs in the context of the crisis, aimed at these two objectives. These include, for example:

- **Customer experience:** Flexibilization and adaptation of offers; on-demand services to replace fixed routes; acceleration of MaaS, new business (B2B) offerings; incentivization of multimodal trips benefiting the overall system, promotions and incentives to rebuild patronage; acceleration of digitalization; new prebooking processes; better data analytics and predictive capabilities.
- **Operational resilience:** New agile crisis management processes; new technologies for contactless accessibility, passenger identification and tracing; flexibilization of staff schedules and tasks; adaptation of procurement and spare-part management approaches; new cleaning and sanitation approaches; asset repurposing; adaptation of capital investment approaches.

Overall, we identified three game changers for operators to rebuild customer relevance and trust and improve operational resilience:

- **Game changer #4 Build intimacy and proactively engage with clients:** Build better understanding of specific clients’ (B2C) needs; improve passenger information (availability, relevance, reliability, timeliness, personalization; proactively engage with companies and schools to influence mobility patterns, complementing B2C approaches by business-to-business-to-clients approaches (B2B2C).
- **Game changer #5 Accelerate digitalization of both offerings and operations for preference and resilience:** Digitalization of 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 digitalization of operations.
- **Game changer #6 Evolution of established crisis management approaches to better anticipate risks and improve resilience of operations:** Develop forward-looking

risk management approaches based on artificial intelligence and machine learning methods and supporting technologies; develop recovery scenario planning and business continuity plans; set up crisis management and rapid-response schemes for increased agility and flexibility in planning and operation.

How to move forward

The COVID-19 crisis has been, in many ways, a defining moment for mobility in cities. Amid the damage and disruption, it has shown for the first time in practical terms that mobility could actually be very different in the future. It has caused society to reflect and reassess its values and priorities in what could be a quite fundamental way, highlighting the importance of issues such as health, hygiene, the environment and home life, as well as speed, convenience and consumption.

The COVID-19 crisis therefore offers a unique window of opportunity for authorities and operators to significantly reshape mobility systems. They can do this by taking “no regret” actions to address established trends, which will deliver major benefits even if the recovery is fast and life does return to something like the pre-COVID world. This is infinitely preferable to overreacting and taking wrong decisions “in a moment of fear”, or conversely, doing as little as possible and gambling that the world will go back to the way it was before.

We believe that the **six game changers** we have outlined in this report will help governments, authorities and public transport operators, and “new” mobility solutions providers to shape the post-COVID future and provide the necessary strategic options and insurances to navigate the uncertainties.

Changing the basic paradigm of mobility systems is hugely challenging, and up to now, most cities and countries have struggled to make the sort of fundamental changes needed to move towards sustainable, resilient and human-centric urban mobility systems. Despite, or even because of, the economic stress that we will see over the coming years, now could be the time for stakeholders to act together to make it happen. Transport authorities have a critical role to play to accelerate change by “framing” and “enabling” the mobility system. PTOs and MSPs also have an important role to play in reinventing their offerings and innovating to increase their relevance and resilience. Mobility is today an interesting playing field for all players in the mobility value chain, including Car OEMs, advance digital solutions suppliers and investors, with strong value creation potential. Achieving success will require vision, creativity, courage and entrepreneurship – but now could be our best opportunity for decades.

1. Setting the scene

It is clear to all that mobility systems have been drastically affected by the COVID-19 pandemic. As a result of lockdowns, social distancing and hygiene requirements, demand for personal mobility has plummeted while operational complexity has increased. At the same time, demand for e-commerce and home delivery has exploded:

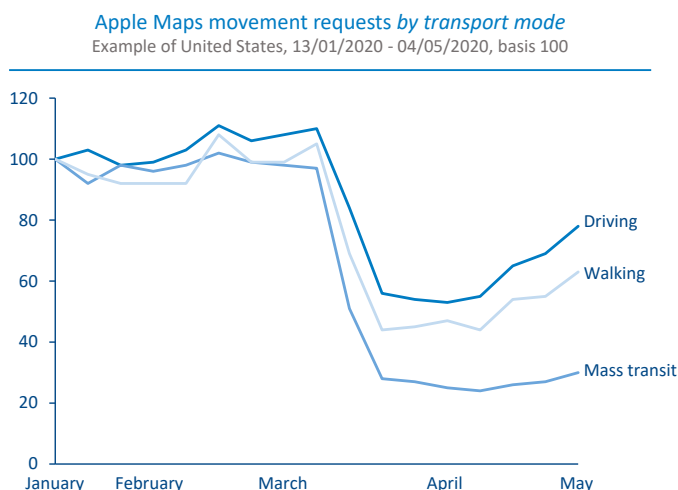
- **Plummeting demand:** As shown in Figure 2, there were decreases in overall mobility demand of up to 90 percent during lockdown, with decreases of 40-70 percent continuing during the recovery period (May-June 2020). This has been accompanied by an increasing share of private mobility (cycling, walking, cars) as people seek to maintain social distance during journeys.
- **Loss of revenues and increased operating expenditure for mass transit:** Apart from lower passenger demand, vehicle capacities have also been reduced, sometimes up to a factor of ~ 4 to enable social distancing during the initial lockdown, and lowered occupation has led to a major reduction in farebox revenues. At the same time operating expenditures have increased due to additional health and hygiene measures and to enable continued operations and services while respecting social distancing.
- **Service suspension for mobility solution providers (MSPs):** Most shared and micro-mobility solutions providers have had to suspend services except for some essential passengers, such as healthcare workers. Some have formed

new partnerships for transport of goods such as groceries, pharmacies and restaurants. Some MSPs have undergone massive cost-cutting (for example, in the US, Bird laid off 30 percent of its worldwide staff) and market consolidation is increasing (for example, the new round of funding of Lime led by Uber, with the acquisition by Lime of Uber's bike and scooter business, Jump).

- **Boom of e-commerce and home delivery:** The shift towards e-commerce has been drastic. For example, there has been an increase of up to 35 percent in e-commerce activity in the US, with Amazon's valuation increasing by 40 percent since the beginning of the year. Last-mile delivery activity has also boomed, with home delivery rates more than doubling in some countries.

No one can predict with any certainty the duration of the economic recovery, or whether it will be V, U, W or L-shaped. However, most observers expect a "new normal" after the recovery phase which will not be the same as the pre-COVID world. While the full extent of the change may be uncertain, all mobility players need to prepare for the post-COVID world by taking the most appropriate strategic and operational options and insurances as mitigation if unforeseen scenarios unfold. This means proactively developing longer-term, forward-looking strategies, as well as the immediate priorities of crisis response and recovery. We summarize this as the "5F approach²" (Figure 3):

Figure 2: Reduced mobility demand by transport mode and by country during the Covid19 crisis



Source: Apple Maps mobility trends report

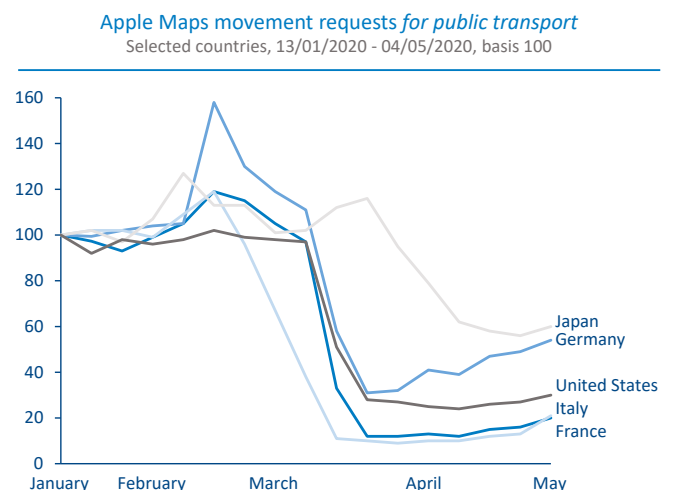
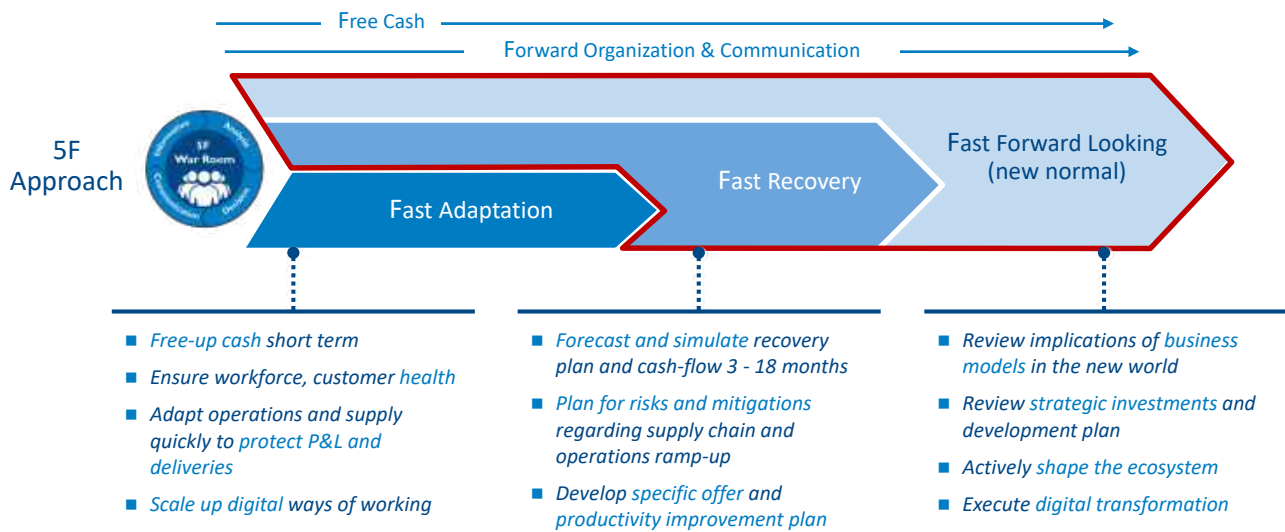


Figure 3: The 5F Approach – Keeping healthy while preparing for recovery and future growth



Source: Arthur D. Little

Even though the crisis will be painful for many, there are also significant new opportunities emerging from the disruption. Will the mobility industry be able to make the most of the disruption to overcome the barriers, exploit the opportunities and reinvent our mobility systems?

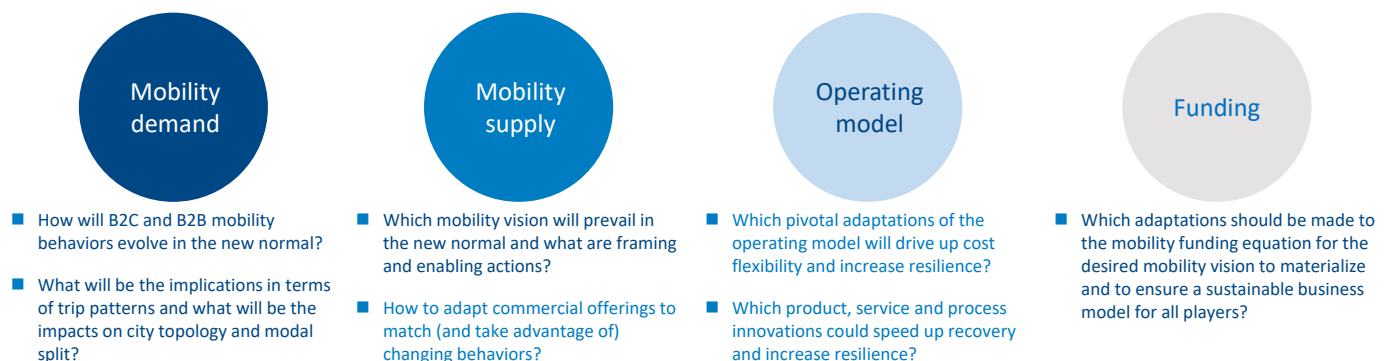
In order to shed some light on this, Arthur D. Little, in collaboration with the UITP, initiated the "Future of Mobility post-COVID" study, with specific focus on what mobility players need to do to manage the ramp-up and navigate the uncertainties of the post-COVID world. From May to July, we engaged with leaders and top executives from over 30 organizations across the world, covering transport authorities, mass-transit operators, MSPs (providing "new mobility" services), and professional associations, to exchange views on the impact of the crisis, actual and planned responses, and insights on the longer-term future. We are very grateful for their excellent contributions. The study focused on issues across four areas: demand, supply, operating model and funding (Figure 4):

This report covers the results of the study and is structured into four main chapters:

- What **new mobility patterns** do we expect to see in the post-COVID world?
- What are the opportunities arising from the crisis to **rethink mobility systems** to become more sustainable, resilient and human centric?
- How can mobility operators and MSPs adapt their **offerings and operating models** to meet post-COVID needs and increase resilience?
- What should executives in different parts of the mobility system do now to **prepare for the future**?

"We are at a time where we can extract most value from international comparisons because of the level of uncertainties in the aftermath of the crisis"
 [Transport authority executive]

Figure 4: Overview of the focus questions addressed by the study



Legend:
 Dark blue: questions at system level
 List blue: questions for mass-transit operators/MSPs

2. Mobility patterns in the post-COVID world

2.1 Indications from initial surveys

A number of surveys have already been carried out, gauging opinions and expectations of the ways in which mobility patterns will change. In Figure 5 below we have summarized the results of some of these.

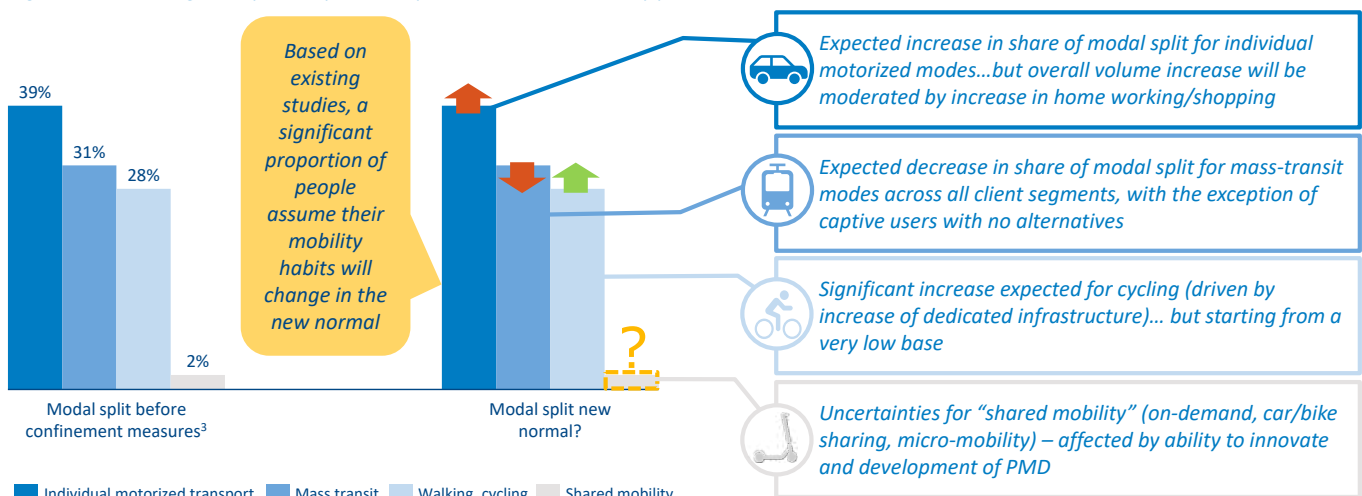
Overall, the initial surveys showed that a significant change in mobility patterns and behaviors is expected:

- The share of **individual transport** (bike, walking, cars) in the modal mix is generally expected to grow in response to social distancing and hygiene concerns, although there is a

large range of expectations on the scale, ranging from zero to more than 50 percent. Biking and walking are encouraged by many public authorities through the creation of new “green zones”; cycle lanes and pedestrian areas. The “shift to cars” is already a reality in China, with massive traffic jams already observed in several cities.

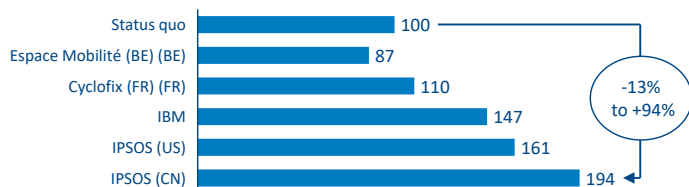
- Similarly, the share of **mass transit** in the modal mix is expected to decrease in the short term, although there are many captive users who are not able to switch modes.

Figure 5: Existing surveys on expected impact of COVID on mobility patterns^{4,5,6,7,8,9,10}

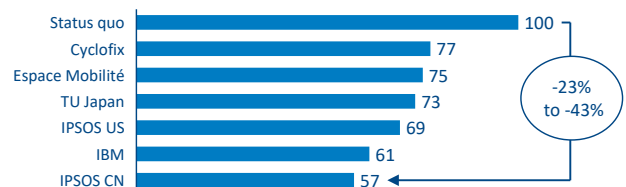


Source: Arthur D. Little

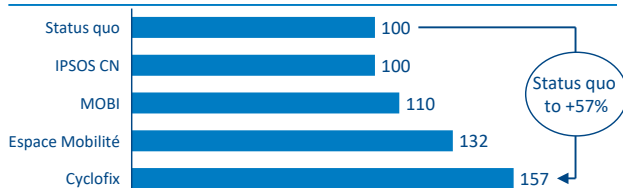
Expected impact of COVID-19 on car usage



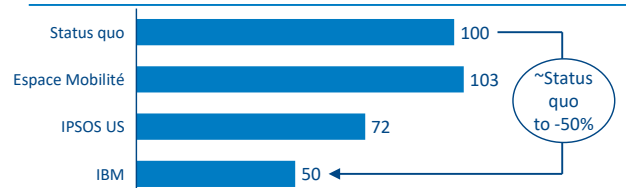
Expected impact of COVID-19 on mass-transport usage



Expected impact of COVID-19 on walking/cycling



Expected impact of COVID-19 on shared mobility



Source: Arthur D. Little, survey review, Espace Mobilité: N= 3,000; Cyclofix: N= 1,369; IBM= 14,000; IPSOS US= 1,000; IPSOS CN: 1,820; TU Japan: 1,038; MOBI: 614

- The impact on **shared mobility** is less clear from the surveys, although in general a decrease is recognized in the short term due to suspension of services, but with the potential for a quick rebound when restrictions are fully lifted, assuming that customer trust returns.

However, these surveys are only indicative and must be treated with caution. The samples in most cases are limited in size, subject to bias, cover different time horizons and are greatly influenced by the prevailing public sentiment at the times of the surveys concerned, which as we have seen has changed from week to week.

2.2 Analysis of the impact of COVID-19 based on key trends

A more reliable approach to assessing the impact of COVID-19 on long-term mobility patterns is to assess the extent to which known key trends impacting mobility systems are likely to be affected. From our study inputs we have identified 12 impacts of the crisis across trends in three dimensions: Global, Behavioral and Technology/Market (Figure 6):

Impacts of COVID-19 on global trends

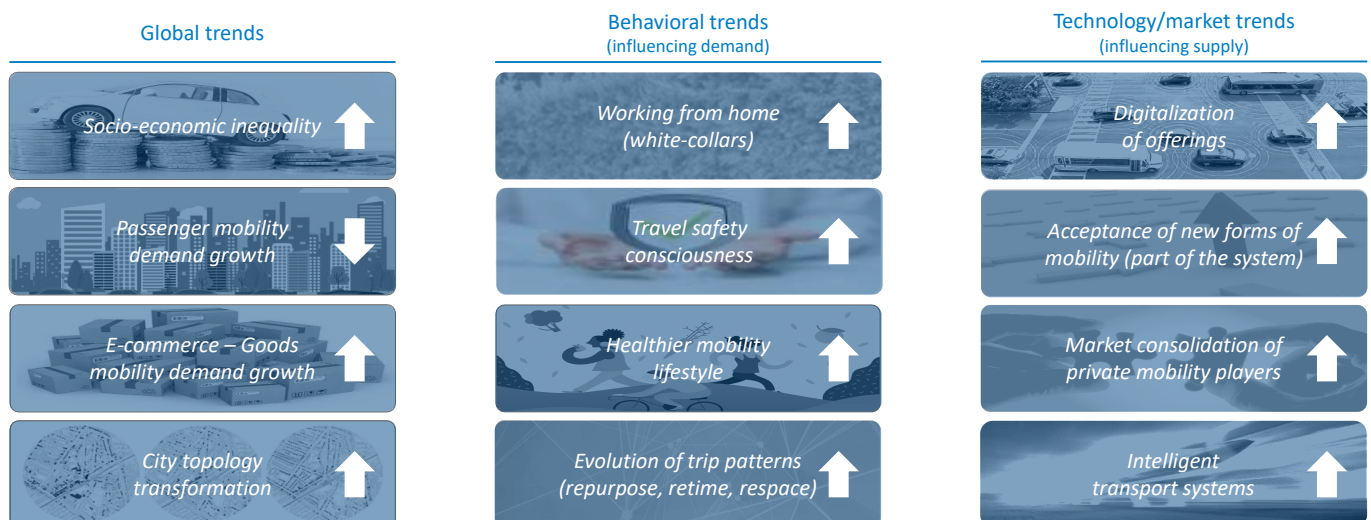
There are four global trends affecting mobility demand and supply which are expected to be significantly impacted by the COVID-19 crisis:

- **Greater socio-economic inequality affecting mobility demand and mode utilization:** A deep economic downturn is now upon us – for example, a GDP decrease of 7.5–9.3 percent is forecast for OECD¹¹ countries in 2020. This will lead to reduced household budgets, including budgets for mobility. Greater unemployment is also certain – for example, an increase from 5.5 percent in March to 8.4

percent in April alone was reported for OECD countries.¹² This will lead to reduction in the volume of trips, changes in trip purpose (less home-to-work trips) and respadding of travel (less travel during peak time, more spread during the day). Lower-income individuals and blue-collar workers are more likely to revert to mass transit to get to work, as they have less choice. Economic hardship could therefore drive increasing inequality in mobility systems, with individual travel or non-travel favored by those who can afford it and mass transit for those who cannot.

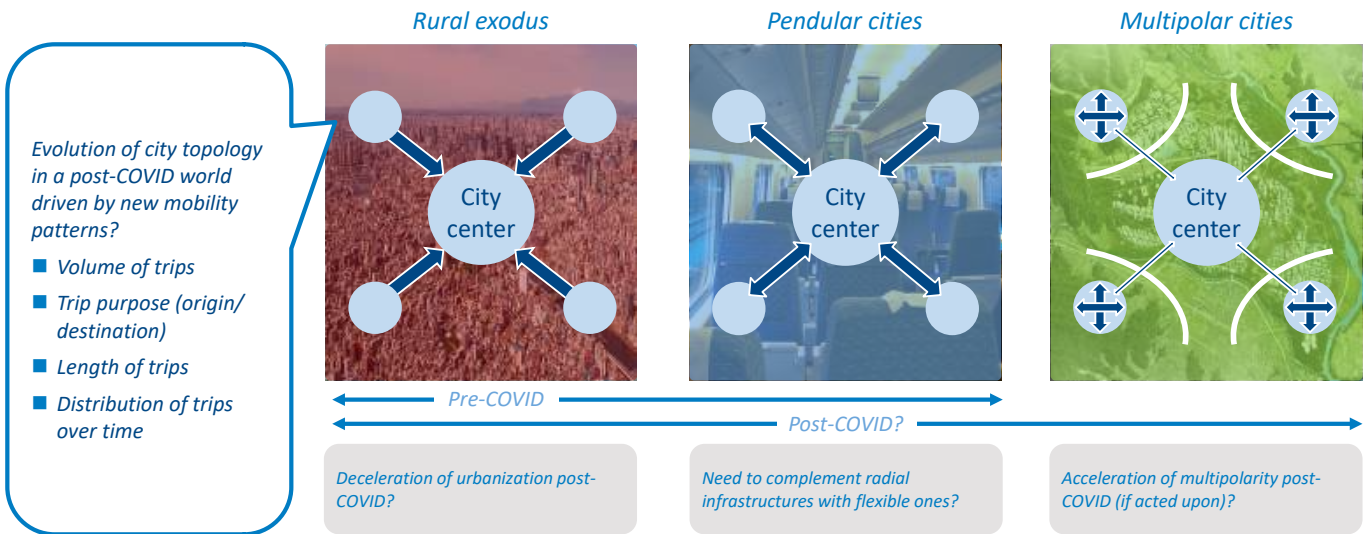
- **Reduced passenger mobility demand growth in cities:** Before COVID-19, urban mobility demand was set to boom, with the urbanization still ongoing and global demand for passenger mobility in urbanized areas set to double by 2050 compared to 2010 (based on passenger km/year).¹³ Our analysis indicates that COVID-19 will not reverse the growth trend – the populations of cities will continue to grow faster than the overall growth of the global population – however, there is likely to be a deceleration in the rate of growth of passenger mobility demand in the coming years. This could be driven by several factors: economic stress as described above; increased working from home (WFH), especially in cities with large service and administration sectors; enduring reductions in culture and leisure activities; temporary reduction in tourism and business travel; and acceleration of e-commerce and associated reduction in personal travel (see below).
- **Acceleration of e-commerce and demand for goods:** Demand for last-mile delivery was already set to triple by 2050,¹⁴ but the crisis has further accelerated 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

Figure 6: Impact of COVID on affected urban mobility trends



Source: Arthur D. Little Future of Mobility lab and UITP

Figure 7: Impact of mobility patterns on city topology in a post-COVID world?



Source: Arthur D. Little Future of Mobility lab and UITP

was an increase of more than 70 percent in France¹⁵); and increased availability of micro-delivery services (for example, ride-hailing solutions were diversified into goods delivery during the crisis).

■ **Acceleration of city topology transformation:** Cities have grown over the last century as millions of people have migrated from rural to metropolitan areas in the quest for better safety, jobs, education, and lifestyles (see Figure 7). However, in recent decades **pendularity** has been a key trend, whereby dwellers have moved outside cities for reasons of affordability, environment, space and quality of life, and commute frequently for work and leisure, causing congestion at peak times. A more recent trend in certain cities has been **multipolarity**, where progressively, smaller communities around the original center have started to flourish and become partly self-sustaining reducing the need to commute on a regular basis and thereby releasing the pressure on city centers while making them more pleasant and attractive.¹⁶ The COVID-19 crisis will challenge some of the guiding principles of mobility patterns and topology transformation. Multipolar city development, implying shorter travel distances to work and play, could be accelerated in the post-COVID world due to the increasing public interest in a greener environment, influenced by the experience of lockdown. Cities which had been already pushing towards multipolarity pre-COVID are now seeing an opportunity to accelerate the achievement of their plans. Pendular cities, which have often made important investments (or have plans to invest) in heavy radial mobility infrastructure, may need to complement those investments with more flexible ones to accommodate reduced commuting demand and the increased shift towards multipolarity.

Impacts of COVID-19 on behavioral trends

There are four behavioral trends affecting mobility demand which are expected to be significantly impacted by COVID-19:

■ **Acceleration of working from home (WFH) and flexible working hours:** Greater 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.¹⁷ However, the confinement resulting from the crisis may have been long enough to build new habits which will 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, with the attendant increased risk of infection in crowded transport modes. Similarly, staff have realized the advantages of homeworking, such as more time with families and avoidance of the costly and time-consuming commute. This is very likely, therefore, to become a major permanent trend. However, the limitations should also be recognized: 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 traveled) and, importantly, a flattening of the critical morning and evening peaks.

16 The “15-minute city” introduced by Carlos Moreno (associate professor at the Paris IAE-Panthéon Sorbonne University in France) is an illustration of the multipolar concept, promoting a true shift to a human-centric city design: within 15-minute intervals, each neighborhood should fulfill six basic social functions: living, working, supplying, caring, learning and enjoying

- Acceleration of travel safety consciousness (fear of infection):** Safety has always been a central issue for mobility systems, but the choice of mobility modes during the crisis has been heavily affected by health and hygiene concerns. In the aftermath of the lockdown, there has been a deficit of trust towards mass transit and shared mobility, driven by the perceived risk of infection from contaminated surfaces and the challenge of maintaining physical distancing. While trust is likely to be regained in the medium term, increased safety consciousness is here to stay, and this requires a step change in levels of cleanliness and sanitation from operators.

“This is a wakeup call towards mass-transit operators to further improve our cleaning process and look for available technology to mitigate those risks in order to regain trust”
[Mass-transit operator executive]

- Acceleration of adoption of healthier mobility modes:** The lockdown has further highlighted citizens’ increased appetite for healthier lifestyles, including increased interest in active mobility: walking, cycling and other private mobility devices (PMDs) such as privately owned e-scooters. For example, electric bicycle sales roughly doubled (Van Moof recorded increases of 184 percent and Cowboy 230 percent versus the previous year up to April). In the UK, 1.3 million electric bicycles were sold from January to May 2020, compared to only 508,000 cars (some 20 percent of which were electrified). The increase in PMD adoption has been driven by perceived hygiene advantages, reduced safety concerns due to empty streets, and more time for reflection about personal health and physical condition. In some cities, the interest has also been fueled by subsidies given by authorities to individuals (e.g., up to EUR 750 for individuals to purchase electric motorcycles in Madrid). However, favorable weather conditions from March to May have also been a factor in some parts of the world, and the trend may fade during the winter period.
- Evolution of trip patterns (Repurposing, Respacing, Retiming):** The global and behavioral trends described above collectively will affect trip patterns. While a slight deceleration of passenger mobility demand in terms of total kilometers traveled is expected in cities, the number of trips per capita is expected to remain stable. However, we expect some Repurposing of trips (fewer trips to workplaces, more for home needs), Respacing (more short, local trips) and Retiming (flattening/staggering of peak hours across all modes). There is uncertainty about how much peak flattening will continue post-lockdown, with some cities seeing continued flattening and others seeing

rapid reformation. Flattening of the peak has huge potential benefits for productivity in cities, including goods as well as people. As we have shown above, an increased share of PMDs and cars at the expense of mass transit is likely in the short term, but this is not expected to last into the medium term. Evolution of the modal split will also vary by city, depending on, for example, the proportion of white-collar versus blue-collar jobs and, in the longer term, the pace at which multipolarization evolves.

Impacts of COVID-19 on technology and market trends

- Acceleration of digitalization:** The well-established digitalization 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.¹⁸ Within the mobility ecosystem the crisis is driving public transport operators to accelerate the digitalization of their offerings (e.g., acceleration of the digitalization 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 personalization of the client information (e.g., tailored messages considering client preferences). Similarly, acceleration of digitalization has also occurred for reasons of operational resilience – for example, flexibilization of planning, automation of cleaning. This will be further explored in Chapter 5.
- Acceptance of new forms of mobility as parts of the system:** Actions taken by many private mobility solution providers during the crisis demonstrated the positive contribution they can make to increasing the resilience of our mobility systems. For example, several on-demand and micro-mobility players extended their offerings to healthcare professionals and nonprofit bodies responsible for delivery services, or even offered free rides. Moreover, many MSPs have been establishing new partnerships (e.g., with local restaurants, groceries, pharmacies) to quickly adjust to new demand for services. Historically new forms of mobility did not always benefit from good reputations with mainstream transport authorities, but the crisis has increased public perception of their value and triggered reflection by some transport authorities on further partnership and integration models, whereby some private on-demand, shared or micro-mobility players could be considered, at least in part, integral to the “public mobility system” being delivered under the public service obligation (PSO). This is especially relevant when they can efficiently and effectively complement mass transit, for example in the first and last mile and in less densified areas that do not justify public transport coverage.

- **Acceleration of market consolidation of private mobility players:** Market consolidation is expected to accelerate, driven by falls in revenue due to the ongoing economic downturn, as well as the repercussions of suspension of activities and collapsing demand during the crisis itself. Examples during the crisis include Lime’s \$170 million funding round, including the acquisition of Uber’s electric bike and scooter operation Jump, Waymo raising \$3 billion in venture capital, Didi (the “Uber of China”) raising \$500m for autonomous mobility and Intel acquiring Moovit (MaaS solutions) for \$900 million. However, higher risk aversion from investors, reflecting the uncertainties in future mobility demand in the aftermath of the crisis, may also drive private MSPs to look for alternative financing models. This may increasingly involve getting closer to city authorities and gaining access to public subsidies in exchange for guaranteed contributions to mobility PSOs (as mentioned above).
- **Acceleration of enablers for intelligent transport systems (ITSs):** The pandemic accelerated the need for multimodal ITS integration, including – as mentioned above – integrated ticketing, payment and real-time passenger information. These are critically important to manage safety-related aspects such as physical distancing, contactless transactions and modified timetables. More broadly, data reinforced its status as being the “new oil” during the crisis, and there is now more openness on the part of PTAs and PTOs towards data-sharing policies. (For example, deployment of data sharing is a requirement of the ITS Directive/NAP in Europe and, while several nations are still lagging behind, the COVID-19 crisis was reported by many authorities as accelerating progress). Furthermore, data sharing, integrated ticketing and payment are all important enablers for Mobility-as-a-Service (MaaS) platforms, as will be further explored in Chapter 4.

2.3 Conclusions

The following conclusions may be drawn on mobility patterns in the post-COVID world:

- In the medium- to long-term, the crisis is likely to accelerate a number of pre-existing trends affecting supply, demand and structural change within mobility systems, in addition to short-term deceleration of passenger mobility growth rates.
- The duration and slope of the recovery from the current crisis, and whether it will be followed by subsequent crises, will, of course, strongly influence the scale of the impacts described, as some of the impacts may be seen as precursors which may soften rapidly in the case of fast recovery. It is important not to be caught up in the hype and

fear surrounding post-COVID predictions, but at the same time, it cannot be assumed that impacts will be limited.

- Apart from the extent of the crisis itself, another key driver that will have a major influence on whether mobility systems will see lasting change is the ability of policy makers, as well as (public and private) MSPs, to seize the unique opportunity provided by the crisis to accelerate a mind-set shift in mobility behaviors and a structural shift in the way mobility systems are organized within and around our cities. This will be addressed in the next chapter.

3. Opportunities to shape more sustainable, resilient and human-centric mobility systems

3.1 An opportunity to shape the future of mobility in cities...for those that can seize it.

Diseases shape cities. Some step-change developments in urban planning and management, such as the first modern underground sewer system in London, were developed in response to sanitary crises. The aftermath of the COVID-19 crisis provides us with the opportunity to step back and reflect. As a direct result of the lockdown we started witnessing actions by governments all over the world which could indicate the start of a different way to plan and manage cities. But to what extent do we believe this crisis could be a real trigger for lasting change towards more sustainable, resilient and human-centric cities? And if so, what are the requirements to make it happen?

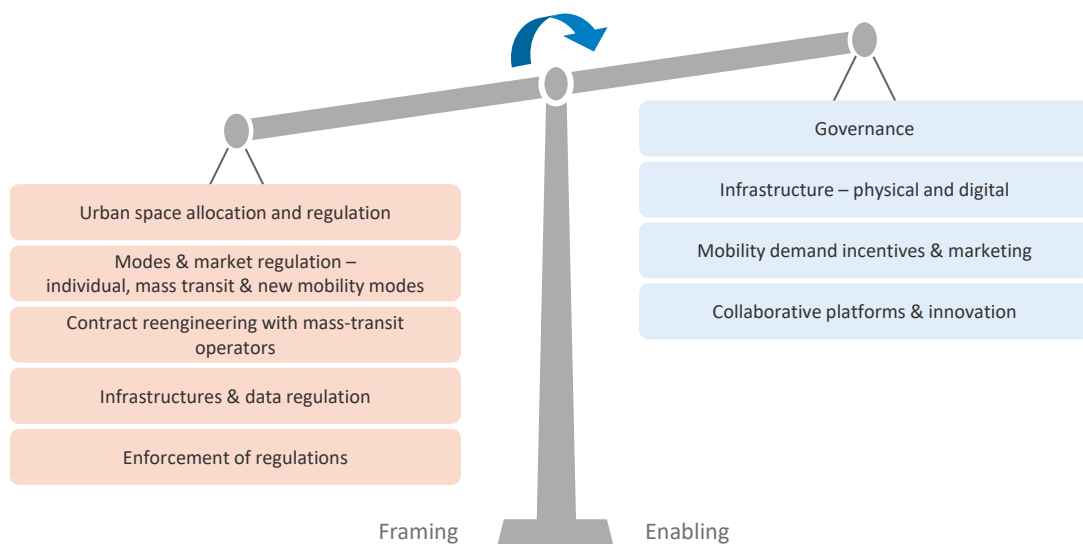
While the crisis has had, and will continue to have, tragic consequences for many people, one of the upsides is that it provides a unique opportunity for innovation. For example, in terms of mobility systems:

- The crisis was a “life-changing moment” for everyone, and it is easier to change mobility behaviors during such moments. Increased public acceptance of change lowers the risk for politicians and officials to become innovation leaders rather than laggards.

- With the reduction of mobility demand and the significant reduction of car traffic, city centers have become “sandboxes” where new measures can be tried out. There is also less risk of immediate controversy if new measures are explored which restrict cars.
- City authorities and private actors can leverage the momentum from raised public awareness of environmental issues during the lockdown to accelerate the transition to sustainable mobility.
- Responding to the crisis has often required rapid action, circumventing slow urban-planning processes. Now that the “art of the possible” has been demonstrated, there is a good window of opportunity to build on the lessons learned and complement typically long-term urban and infrastructure investments with smart and impactful short- to medium-term investments.

In the previous chapter, we showed that certain mobility trends are being significantly impacted by the crisis, and that the scale of impact will depend greatly on the duration and slope of the recovery. However, we also concluded that major, lasting change towards realization of a more sustainable, resilient and human-centric mobility system will depend a great deal on whether key players seize the opportunity. Among the key players that can

Figure 8: Framing and enabling actions for sustainable, resilient and human-centric mobility systems



Source: Arthur D. Little Future of Mobility lab and UITP

have the greatest impact are city governments and transport authorities. For those authorities that are committed to effecting significant change, two broad types of action can be undertaken (see Figure 8):

- Authorities can act on the system by regulating each of its components (**Framing**). The range of possible actions for regulation and enforcement spans urban space, modes, markets, infrastructure and data.
- Authorities can also enable other system actors to move things forward coherently and effectively (**Enabling**). Enabling actions include governance arrangements, investments in vital physical and digital mobility infrastructures, measures to influence behaviors and platforms for collaboration.

Enabling actions are often identified by authorities as being the more challenging, because they often require courage and

willingness to act outside traditional boundaries, sometimes beyond authority remits, and are dependent for their success on effective coordination and collaboration with other actors.

Many of the authorities we engaged with in this study had already been taking new framing and enabling measures during the crisis. In some cases, these relate to acceleration or broadening of existing plans, but in other cases they are new measures, aimed at using the crisis as an opportunity to introduce new innovations and change long-term plans. In the following table we have collated some of these key framing and enabling actions, based on our discussions with authorities and MSPs (public and private). While the list could not be considered exhaustive, we believe it provides a valuable overview of the nature of actions being undertaken to shape the future of mobility systems.

Framing actions

Levers	Actions
Urban space – Allocation and regulation	Intensification of road repurposing from private mobility and/or parking spaces (or, in some cases, from dedicated bus lanes) to active mobility and PMD (see also Enabling – Infrastructure).
	Shift from car-centric street to human centric. Introduction of “slow street”/“safe street” networks that prioritize pedestrians and cyclists and limit individual car access.
	Reorganization of urban design to cater better for urban logistics.
	Temporary reallocation of streets and parking spaces for other functions, including moving to more dynamic management of the curb (reallocation of space across different times of the day to accommodate, for example, increased delivery needs or leisure activities requiring extended outside seating).
Modes & market regulation – Transversal	Concerted acceleration of the establishment of “intermodal mobility master plans” at national or city level to bridge the gap between urban space allocation and mobility modes, and to structurally improve connection nodes while adjusting operating modalities to the nature of the flows.
Modes & market regulation – Individual motorized mobility	Acceleration of regulation of standards related to polluting cars (SUV, old cars).
	Rethinking of road-user charges or introduction of congestion charging to ensure that the road network does not deliver growing congestion due to increased road freight vehicle activity driven by the boost of e-commerce and home delivery.
	Such initiatives are particularly relevant to avoid an unwanted shift from public transport to private vehicles. It would provide funding to balance the revenue loss from public transport and contribute to other initiatives in mobility investment.
Modes & market regulation – New mobility	Accelerated regulation of new mobility solutions. This was best illustrated during the lockdown by New York City, which issued a new state law in April 2020 to legalize the use of e-bikes and e-scooters and will shortly have an accelerated launch of a large bike-sharing scheme.
	Regulation of new mobility to encourage test & learn approaches, for example: <ul style="list-style-type: none"> ■ Regulatory sandbox for shared, on-demand and micro-mobility solutions. ■ Regulatory sandbox for drone delivery. ■ Acceleration of regulation towards autonomous mobility. Provision of targeted subsidies for trips performed by shared or on-demand mobility solutions when those trips are considered valuable to the system, thereby influencing both supply and demand. (The aim of this measure is to signal which trips are valuable to the system, for example, by incentivizing MSPs to increase the geographical coverage of their offers).
Contract reengineering with private mass-transit operators	Major subsidies granted by governments to offset the negative impacts of the crisis on private mass-transit operators’ revenues, especially those with “net cost contracts” whose margins rely very heavily on passenger fares, or those with “gross cost contracts”, including significant revenue incentive schemes (See also Box below).
Infrastructure regulation – Parking and “curb management”	Flexible time and zone management of on-street parking with measures such as adjusting parking fees during the day, reducing parking spaces, fixing time limits, using real-time information to inform users about congestion, and managing access to restricted areas.

Levers	Actions
Data regulations	<p>Development and deployment of data-sharing policies, reflecting the increased importance of data for tracking and passenger information purposes, as well as the integration of ticketing and payment, which constitute key requirements for a MaaS platform. In Europe this includes accelerated deployment of the requirements of the ITS Directive/NAP.</p> <p>Accelerated evolution in Europe from an "open data" policy for mass-transit data implying full opening of data without conditions, towards a "shared data" policy implying openness of data under conditions of reciprocity and usage.</p> <p>(See also "Accelerated investment in MaaS by public transport authorities" under Enabling actions).</p>
Enforcement	<p>Increased monitoring of the road utilization and operations of new mobility solution providers in order to better control compliance with regulations and allow for enforcement (including penalties) in case of non-compliance. This can include, for example, operational constraints such as vehicle fleet size, parking requirements, and safety requirements, as well as speed.</p>

Box 1: Urban space – Why does it matter so much post-COVID?

The ongoing tension between automobile-centric versus human-centric cities is a challenge that urbanists have been grappling with for the past 75 years. The current way of allocating urban space has reduced the resilience of cities. Space and time have been, for a long time, the key parameters on which to design and measure the performance of our transport systems: time is valuable to individuals while space is precious to public authorities and society. Collectively for society, space is the scarcest resource and cities realize that they need to allocate it more efficiently. This is even more important in the context of imposition of physical distancing requirements. Despite appearances, street configurations are not set in stone and cities are already taking actions to reallocate space to allow for physically spaced walking and cycling.

The pandemic indirectly led to reassessment of the function of public spaces. It opened the eyes of the public towards an interruption to the status quo and an evolution towards new functions which were not foreseeable in the pre-COVID world, for example, positioning public spaces to fulfill an essential "stay function," not only a "passage function".

Building on these experiences, several authorities are now realizing opportunities to undo some of the mistakes of the past in which cars were given priority over human beings, and are now contemplating permanent shifts in mobility infrastructure to facilitate active transportation, multi-modality, and human-centric cities. As well as improving quality of life, such shifts can improve cities' economic performance.¹⁹

Box 2: The implications of contractual design and specification for private mass transit operators

During the pandemic, mass-transit operators suffered from plummeting demand while public service obligations required them to keep services running with increased operational costs due to new hygiene and health measures.

The financial impact for operators has been very much dependent on the nature of their contracts with governments. Operators with "net cost contracts" whose revenues relied heavily on passenger fares (as it is for instance the case for some contracts in the UK and the US), or with "gross cost contracts" with significant incentive schemes (as is the case in Sweden), were severely hit during the crisis. For operators with gross cost contracts paid on a per-kilometer basis regardless of the number of passengers carried, the detrimental impact has been more limited. Revenues of transport authorities were severely affected too, including notably passenger fares (when collected by the authorities), revenue from congestion charging and property taxes. In London for instance, the government agreed an emergency funding package of approximately £1 billion to allow TfL to run public transport safely between May and October 2020, as COVID-19 has had a catastrophic impact on TfL's finances – as it has everywhere in the UK.

Such public interventions may however not be sustainable in the long term, and moving forward, other levers to drive more flexibility and resilience in transport operators are currently under investigation by several transport authorities – particularly those authorities which will have to launch new tendering procedures in the next few years. Among the levers currently being contemplated are: the introduction of more service flexibility, e.g., allowing flexing up or down of the volume of services or temporary replacement of some routes with on-demand services; the introduction of more dynamic governance mechanisms to improve "real time" decision making; and the inclusion of insurance requirements in the contract to mitigate the financial risk of collapses in demand in the case of crisis. In all cases, these changes reflect the evolution of the relationships between authorities and operators from traditional client-supplier style towards partnership.

Enabling actions

Levers	Actions
Governance	<p>Rethinking of the governance model towards more integration, efficiency and collaboration across all actors (public and private), not only in planning, but also across execution.</p> <p>Establishing a unified mobility control center to steer and optimize system flows, supported by an enabling data platform with access rules and arbitration arrangements.</p>
Investments in physical mobility infrastructure	<p>Reassessing investments in mobility infrastructure to:</p> <ul style="list-style-type: none"> Focus on those investments which will be a stimulus to re-boost the economy. Delay or deprioritize certain investments to meet new, reducing public funding constraints. Focus on reversible projects to avoid investing in high-cost infrastructure that may not be compatible with future needs. <p>Examples of post-COVID new or accelerated mobility infrastructure investments include the following:</p> <ul style="list-style-type: none"> Extensive cycling-network extension to nudge active travel (walking, cycling) and personal mobility devices (PMDs, e.g., e-scooters and other devices). Introduction of temporary "pop-up lanes" (mostly in Europe), some of which are likely to be perpetuated. Development of robust infrastructure for pedestrians to improve the walkability of cities (e.g., increasing the size of sidewalks). Infrastructure for urban logistics (e.g., urban distribution centers – UDCs). Parking space for micro-mobility (see also Urban space – Allocation and regulation above). Dedicated bus lanes for public transport (see also Urban space – Allocation and regulation above). Planned accelerated development of multimodal mobility infrastructure ("mobility points") in city centers, or at the outskirts of cities, to support new commuting patterns with the aim to improve intermodality between mass transit, active modes (bicycle) and new mobility solutions (shared mobility and micro-mobility). Planned accelerated development of e-mobility charging infrastructure.
Investments in digital mobility infrastructure	<ul style="list-style-type: none"> Planned accelerated investment in MaaS by PTAs, often in collaboration with PTOs, with increased focus on the "disaggregated open MaaS platform" market model. This model involves the development of a public MaaS back end and data lake open to MaaS third-party operators (public and private) to connect and deploy their front-end MaaS business-to-consumer applications. Special mention can be made to Madrid PTO (EMT), which developed during the crisis a MaaS manifesto, "Alianza por un MaaS sostenible", to unlock the potential of MaaS by enhancing trust and balance between public and private actors. Investment in urban logistics digital platforms for essential-goods delivery, for example, by on-demand mobility solutions, delivery scooters or bikes. This includes using volunteers to cater for the needs of the elderly during the crisis, as has been done in Brussels.
Mobility demand management through incentives, marketing & communication	<p>Introduction (or enhancement) of mobility demand management measures to positively drive mobility behaviors. Illustrative examples include:</p> <ul style="list-style-type: none"> Incentives to encourage adoption of soft mobility modes (e-bikes and e-scooters). Incentives to encourage adoption of shared mobility. Discounts on parking for shared cars. <p>Delivering a public relations push, including communication and narratives, to:</p> <ul style="list-style-type: none"> Restore public trust in mass transit, including new safety and health processes and transparency on charges, to avoid the "shift to car". Maintain/reinforce a shift towards a sustainable mobility mix (including on-demand, shared, PMD). <p>Incentivizing business enterprises through tax relief to increasingly favor WFH and arrange employee work hours to support flattening the peaks. Also provide businesses with guidance on how they can support their employees in WFH.</p> <p>Proactive communication towards schools to trigger adaptation of school schedules (starting and closing times) to flatten the peak.</p>
Collaborative platforms & innovation	<p>Accelerated set-up of collaborative platforms to foster public private collaboration – including forging new public-private partnerships, leveraging strengths of both private (funding) and public (public trust) and accelerating development of a win-win logic – and trigger multi-actor innovation and lateral learnings at system level.</p>

“During the crisis, people often predict trends to go against the norm and that are usually wrong in every conceivable way, because they were described during a moment of fear” [Transport authority executive]

Given the level of uncertainty in the future, many authorities stressed the importance of focusing especially on “no regret” actions which would continue to make sense whatever the post-COVID world looks like.

Overall, it is clear from the many initiatives undertaken in the last few months that, despite the challenges, in general authorities are, indeed, attempting to seize the opportunity presented by the crisis, as well as merely managing the crisis itself. This is especially the case for the numerous new *Enabling* actions, where authorities have been typically lagging. This is a positive sign for future mobility systems development.²⁰

3.2 Obstacles for authorities to drive radical change in mobility systems

As we write this report, most transport authorities are still very much occupied with the recovery phase of the crisis, which is itself hugely challenging. As such, it is too early to expect well-developed strategies and plans for longer-term mobility system development for the post-COVID world, and in summarizing the positions of the authorities we have therefore reflected the views of the executives we have interacted with in the study, rather than any publicly declared positions. With this in mind, from our exchanges we can broadly recognize three categories among the authorities we spoke to:

- **“Non-believers”:** A minority of authorities does not recognize any sense of urgency to radically rethink the system. They do not feel the necessity or the need to evolve their ability to further open the system towards further integration of new mobility solutions. They do not expect significant change at system level in the years to come.
- **“Progressives”:** A few more authorities are on the other end of the spectrum; these authorities are fully aware of the need to drastically change mobility policies and were already engaged with this prior to the COVID-19 crisis. They recognize the need to take action to build more sustainable, resilient and human-centric mobility systems. They typically also recognize that this requires a more inclusive approach, further integrating new mobility solution providers as an integral part of the system.

“In times of uncertainties, hope does not bring anything, but plans do. When some factors have the potential to positively influence our mobility systems, we need to shape those so that they can become permanent trends” [Transport authority executive]

- **“Stuck in the middles”:** About half of authorities recognize the need to radically change mobility systems and to further open them up to new forms of mobility, but they are struggling to identify the resources and means in order to make it happen.

If we take a step back from the many individual constraints that each authority needs to deal with, at a high level we believe there are three key obstacles that determine how well an authority is able to positively shape future mobility systems towards being more sustainable, resilient and human centric:

- **Lack of proven ability to be visionary:** Cities that have been doing well during the pandemic, and that are planning to further reshape the system going forward, are often those that already had well-articulated urban mobility visions and mobility plans supported by strong and committed local government. This enabled them to fast-track measures that were already planned. However, there were some notable exceptions in which authorities were able to take bold actions during the crisis, despite not having visionary mobility plans.
- **Unclear accountabilities between government and the transport authority:** While elected city- and regional-level governments are usually best placed to set up mobility visions and define policy priorities, transport authorities are best placed to ensure the execution of this vision through actions. Clear accountability and proper allocation of responsibilities between government and authorities, as well as across different levels (regional, city and local), heavily influence their ability to act. Cities with lightweight transport authorities, and/or low-level relationships with government, will typically have more limited room for maneuvering to effect change. Some authorities are also under increasing scrutiny from government as a consequence of the significant additional public funding they received during the crisis, which may restrict their ability to do new things seen as non-essential or outside their normal scope.
- **Lack of strong personal leadership:** The crisis has illustrated clearly how, given unequivocal urgency and necessity, the enlightened leadership of key individuals in

²⁰ A new digital database was launched in June 2020 by a partnership of international NGOs and identifies global mobility responses to COVID-19, <https://www.covidmobilityworks.org/>

government and transport authorities has been a key factor in making things happen. It is essential to have leaders on both sides who have the capabilities and qualities to both originate/propose ambitious ideas, and to strongly drive action to implement them.

While it is evident that size and available resources limit the type of actions that can be undertaken, ultimately this is not the determining factor and should not be used as an excuse for poor leadership. The crisis showed that cities could do a lot without huge resources, for example, through partnering with relevant third parties or by taking bold actions that were less capital intensive. (An example could be new road markings rather than new infrastructure.)

Overall, it is clear from our exchanges with governments and authorities that the obstacles to change are significant, and there is a shared fear that unless changes are made, the majority of authorities, maybe as many as two-thirds, may not be in a position to do what is necessary to drive the required change.

3.3 Paving the way towards more sustainable, resilient and human-centric mobility systems

So what should be done to remove existing barriers and foster a move towards more sustainable, resilient and human-centric mobility systems? While we recognize only too well that the devil lies in the detail, we have identified three top-level “game changers” for authorities and governments to consider going forward:

Game changer #1: Think and act at system level

The importance of the system approach was brought into sharp focus by the COVID-19 crisis. Mobility in cities needs to be considered a system, whereby the value lies in transversally managing all public and private modes comprehensively, rather than each mode individually. Key aspects include the following:

- Developing a **unified, long-term mobility vision** involving mobilization and empowerment of relevant public stakeholders across all relevant urban policy domains (mobility, urban planning, environment, economic, social), including mass-transit operators, as well as private MSPs (on-demand, shared, micro) and representatives from businesses, associations and civil society. This requires authorities to change their posture towards MSPs to evolve from pure regulator relationships towards a partnership model.

- Implementing **system-level regulation**, with a specific focus on allocation of urban space, tariff integration and data sharing. A key success factor for authorities is to move from mainly regulating mass transit and individual motorized transportation, often managed independently with different levels of regulation for new mobility modes, towards regulating all the mobility modes in a unified way using transversal logic. This will positively influence a shift towards a “shared mobility system”.²¹
- Adopting **system-level execution planning**, for example, including multimodal master planning and guidance on mode allocation. The establishment of an integrated mobility master-plan at city or national level allows the gap to be bridged between urban space allocation and mobility mode design and enables structural improvement of connection nodes while adjusting operating modalities to the nature of the flows. While several such plans already exist on paper, greater focus should be put on their enforcement – this can be enabled by suitable digital architecture. Master plans also need to be supported by the required physical and digital investment plans.
- Revising the **mobility funding** equation, for example, assessing the opportunity to provide subsidies for socially contributive, but economically challenging, trips provided by private MSPs that may be operating with fragile business models.

“It is important for city authorities to understand how – if properly framed – on-demand, shared and micro-mobility modes can contribute to city mobility goals and make selected regulatory changes to remove the barriers to make them more successful” [Transport authority executive]

Further insights on the role that “new mobility” solution providers can have in increasing the resilience of mobility systems, as well as guidance for city authorities to properly frame and enable them, are provided in Box 3 below.

21 The concept of “shared mobility system” is to be understood as the combination of mass transit acting as a backbone and “new mobility” solutions (on-demand, sharing, micro-mobility and personal mobility devices), positioned as first- and last-mile mobility solutions feeding the mass-transit backbone

Box 3: Framing and Enabling “new mobility” solutions providers

It is recognized by most authorities that “new MSPs” (private on-demand, shared and micro-mobility solutions providers) can play important roles in our mobility system by (a) executing trips in less dense areas that would not be economically viable to deliver through mass transit, and (b) serving as feeders to mass transit for the first and last miles, thereby extending the overall scope and attractiveness of shared mobility systems as a viable alternative to the car. This can be especially valuable in a post-COVID world where mobility demand is less stable and predictable. Authorities that rely solely on a traditional public transit network supply (metro, tramways and buses) may face increasing difficulties to achieve inclusiveness across all their served territories in the face of growing economic constraints.

The COVID-19 crisis also clearly demonstrated the potential contribution of new MSPs to system resilience: for example, they were quickly able to adapt to new requirements for stricter hygiene, contactless ticketing and payment, and real-time information (e.g., in the US, New Zealand, Malta, Israel); they directly supported mobility of healthcare workers through free rides, dedicated lines, etc. (e.g., in Germany, France, Emirates); and they pivoted rapidly to transport food and other essential goods (e.g., in the US and UK).

Over past years, authorities were sometimes tempted to consider new MSPs merely as unruly private money-making enterprises which should be required to make financial contributions towards city mobility budgets. However, in practice, COVID-19 has shown that new MSPs often have fragile business models. Many players have exited, and others have retrenched (for example, Uber laying off 3,700 full-time employees in its core division or Bird laying off 30 percent of its workforce).

Authorities should therefore consider what is the most appropriate framing and enabling approach for integrating new MSPs to provide a “win-win” for both parties: helping new MSPs to establish viable financial models (notwithstanding their ultimate dependence on private investment), while ensuring they play their part in ensuring a resilient overall mobility system, and managing the additional risks of their participation, such as congestion and safety.

Having a clear policy framework and set of criteria is the starting point for authorities. Such a framework should typically encompass the following five main dimensions:

- Which **new mobility modes or services** fulfill city goals, cater to citizens’ needs and are sufficiently adapted to the local specifics of my mobility system? This will typically require a criteria-based multidisciplinary assessment of the attractiveness of applicant modes, taking into account current/potential value and contribution to the mobility system.
- With which **minimal conditions** would we feel comfortable seeing new services being tested on our streets (“the rules of the game”)?
- Which are the **right actors to engage with**? While involving international players is relevant to benefit from their expertise and economies of scale, it is also important to involve local partners to benefit from their understanding of local needs and long-term presence.
- How do we **prioritize actions** to ensure that time and money are invested with the best return for the system as a whole? Those actions which provide good future volume potential and are most attractive for the mobility system as a whole should be higher priority.
- How do we guarantee as an authority that agreed **service levels and regulatory requirements** are continuously fulfilled? As always, it is important to place sufficient focus on effective deployment and monitoring, as well as regulation setting.

The framework would require a more agile and surgical approach to subsidy and funding, informed by comprehensive data analytics. For example, authorities may wish to incentivize “socially viable but economically challenging trips” to achieve coverage across less dense areas. This could be achieved via trip-by-trip subsidy where the authority can signal through the pricing which trips are valuable to the system, thereby influencing both supply and the demand. In the same way, multi-modality between new MSPs and mass transit could be incentivized through smart pricing schemes. There are some good examples of this in practice, for example, in US cities such as Detroit and Boston.

Overall, experience has shown that authorities should employ an adaptive “test and learn” regulatory approach – rather than a fixed approach – to secure a win-win model with new mobility solution providers.

“As new mobility solutions operators aim to increasingly be part and contribute to the shared mobility system, it is now time for authorities and MSPs to move from friendly coexistence towards understanding and complementarity”
[Private “new mobility” solution provider executive]

“We believe in a win-win approach with new mobility solutions, but as guardian of the system, we need to find sufficient assurance that new solutions introduced are not creating chaos in our streets”
[Transport authority strategic planning department]

Game changer #2: Foster innovation through public-private collaborations on innovative technology and business model development

Innovation and agility will be more important than ever in the post-COVID world to boost recovery and respond to rapidly changing circumstances. Collaboration between public and private players is one of the most effective means of fostering innovation and has the potential to maximize the leverage achievable with limited public funds. Key aspects include:

- Collaboration on **technology development and implementation**. There are many examples, ranging from artificial intelligence- and machine learning (AI/ML)-enabled data analytics through to digital twinning and new electrification technologies. Public authorities and operators need to increase collaboration with those private companies at the forefront of these technologies in order to maximize the value they can create for the system.
- Collaboration on **innovative business models**. This could include, for example, MaaS front ends, urban logistics schemes, intermodal mobility hubs and many others. While public players bring legitimacy (acting in “public interest”), private players can bring agility as well as the willingness to take entrepreneurial risks in developing, trialing and scaling up new concepts that are not yet proven in the market.
- Innovation **schemes, competitions and projects**. This could include both public and restricted calls for “open innovation” collaborative projects such as trials, demonstrations and pilots, as well as supporting innovation infrastructure such as incubators, accelerators and innovation zones. For example, Singapore’s LTA just announced the accelerated launch during the crisis of its open innovation initiative (the Singapore Mobility Challenge), aimed at pursuing its Land Transport Master Plan 2040 goals.

“Improving collaboration with private players, such as providers of advanced digital solutions as well as car OEMs and other players in the mobility value chain, will be critical to accelerate innovation and drive value in the new normal” *[Mass-transit operator executive]*

It is clear from past experience that public-private collaboration has not always been successful. For example, the public-private partnership model has had a mixed history, with a number of notable failures as well as some successes. Some key factors for making public-private collaborations more effective include, among others:

- Being clear about goals but avoiding over-prescribing the means to achieve them.
- Adopting a partnership, rather than a conventional client-contractor, relationship style.
- Having open and transparent procurement processes.
- Establishing clear rules and principles for intellectual property management and data sharing.
- Being clear about risk allocation between authorities, private players and investors.
- Addressing business model viability early in the innovation cycle.
- Adopting agile approaches with early testing of minimum viable products.

Game changer #3: Set-up of a Unified Mobility Management Model, enabling real-time optimization of mobility flows and assets at city or national level

The COVID-19 crisis has brought the importance of resilience and human-centricity in our mobility systems sharply into focus. It has taught us that changing mobility habits is actually not impossible; that dynamic and personalized provision of information is vital to manage mobility flows in the future (e.g., for social distancing); that comprehensive MaaS, including all mobility modes and system-level optimization, has the potential to meet post-COVID needs and avoid the shift to car if properly framed and sufficiently adopted; and, more broadly, that the crisis has reconfirmed that data really is the “new oil” if future mobility needs are to be met.

Applied in the context of mobility, the technical ability to comprehensively access data in real time across the mobility system as a whole (car traffic, mass transit, on-demand, shared and micro-mobility, as well as of all the associated infrastructures) is creating opportunities in terms of near real-time mobility flow management and mobility asset management that go far beyond what is currently in stock with “traditional” MaaS offerings (even though MaaS is largely still embryonic). Aggregated mobility data is also critical to inform the right mobility planning decisions, justify infrastructure investments and gauge how the implementation of specific mobility measures is contributing to achieving city leaders’ goals.²³

These considerations, as well as the obstacles reported to us by authorities (see section 3.2), all point strongly to the need for governments and transport authorities alike to drive the further development of MaaS by setting up *Unified Mobility Governance Models*. This will ensure effective decision-making at both planned and real-time levels and allow for optimization of mobility flows and assets in the interest of the system as a whole. Key aspects of this Unified Mobility Management Model include:

- A **unified long-term mobility vision** involving mobilization and empowerment of relevant public and private stakeholders (see game changer #1 above).
- A **safe place where data from all mobility providers can be aggregated** (public and private, covering both passenger and goods mobility and all infrastructures), with the public authority acting as guarantor, fully accessible to third parties and not a closed system. This is the so called “Master Mobility data lake”.
- **Standards and protocols for data collection and bidirectional data exchange**, including underlying principles and ethics and mechanisms for value sharing.

- A **public authority back end powered by algorithms** to optimize mobility flows and assets at system level and enforce regulation.
- Setting up a **multi-actor governance approach** for MaaS vision and strategy setting, arbitration and value-sharing, including involvement of government and authorities (across multiple mobility domains), public mobility players, private mobility players, and user representatives.
- **Deploying and empowering actors** so as to make maximum use of their respective capabilities and expertise.

The concept of a Unified Mobility Management Model and its applicability for effective MaaS deployment is further detailed in Chapter 4 below.

4. How MaaS and a Unified Mobility Management Model could contribute in the post-COVID world

4.1 The potential benefits of comprehensive MaaS implementation

In the previous section we identified the development of “comprehensive MaaS”, requiring the set-up of a Unified Mobility Management Model, as one of the three game changers for governments and authorities to respond to the challenges of the post-COVID world. In this section we look in more depth at the potential for MaaS to meet post-COVID needs and the requirements to implement it successfully.

The concept of MaaS has been subject to hype over recent years. However, a comprehensive, widely adopted MaaS has huge potential to move towards more sustainable, resilient and human-centric mobility systems post-COVID, for example:

Users

- Improved customer experience by facilitating optimal mobility choices based on personal preferences (duration, mode type, cost, environmental) and prevailing circumstances.
- Access to real-time and multimodal client information.
- Reduction of the overall budget allocated to mobility (mostly by sharing assets and payment based on consumption, as opposed to the total cost of individual car ownership).

Cities and transport authorities

Behavior orientation towards more sustainable mobility solutions: public transport, walking, cycling, new mobility solutions.

Transport is undergoing a fundamental shift in the way in which data is encoded, produced, processed and used. [...] New types of platform-based, shared services are being deployed for both freight and passenger transport. The ability to find a ride within minutes, to evaluate multiple route options instantaneously, to rapidly, conveniently and affordably share unused freight or passenger vehicle capacity, all were unthinkable a generation ago, but now are taken for granted by many. The future is one where algorithms may orchestrate mobility and access on a scale never before seen”
[International Transport Forum]²⁴

- Extended “amplitude” of mobility coverage (through first- and last-mile solutions), thereby increasing accessibility of mobility to all.

Operators of mobility solutions (public or private)

- Expanded access to all mobility needs expressed, thereby increasing the addressable market.
- Provision of an additional digital channel for communicating and engaging with clients.

Society at large

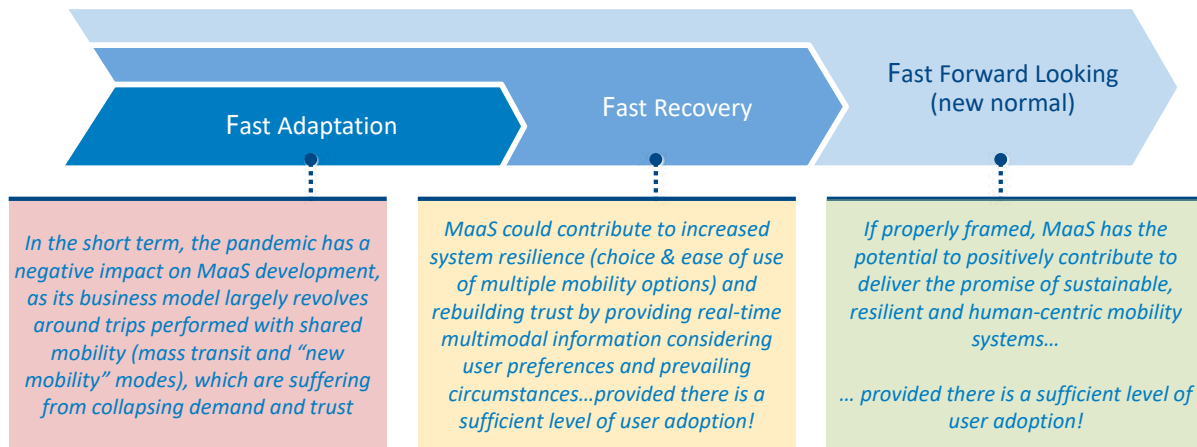
- Depending on the level of public governance incorporated into the development of the MaaS concept, this may have a significant impact on the contribution mobility systems make to the Sustainable Development Goals defined by the United Nations (Sustainable Development Goals).

4.2 The impact of COVID-19 on the further penetration of MaaS

It is interesting to reflect on how COVID-19 could affect the future development and penetration of MaaS (see Figure 9):

In the short term, the COVID-19 crisis is likely to have a negative impact on the scalability of MaaS development, as the MaaS business model largely revolves around trips performed with “shared mobility” modes (mass transit and “new mobility” modes acting as feeders) which have suffered from collapsing demand and trust and builds on multimodal trips, which were also reduced during the crisis.

Figure 9: How MaaS could contribute to post-COVID mobility systems



Source: Arthur D. Little Future of Mobility lab

In the medium term, MaaS can contribute to increased system resilience through providing more choice of mobility options and ease of use. Trust can also be rebuilt by providing real-time multimodal information such as capacity in vehicles and stations, considering user preferences and prevailing circumstances. For now however, this impact is expected to be limited due to the current low level of penetration of MaaS.

“It is essentially important to maintain the general trust in safety of public and shared transport services, and here digital innovations and tools can certainly help. The MaaS operators, as the interface between users and mobility providers, are in a very good position to understand and match the demand and supply, based on the preferences of the users and prevailing external circumstances” [Piia Karjalainen, Secretary General MaaS Alliance]

In the longer term, MaaS certainly has the potential to positively influence mobility patterns and behaviors in a way that will align much better with the more uncertain post-COVID environment.

MaaS B2B offerings could be a catalyst for further acceleration of MaaS, as the openness of companies to adopting flexible working hours and engaging with transit operators is accelerated post-COVID. A suitable B2B MaaS offering, which should ideally be combined with subsidies or fiscal incentives to encourage employees to reduce car usage, can be a powerful combination to encourage a modal shift for the daily commute from private cars towards a shared mobility system with mass transit as the backbone.

New, more flexible pricing schemes for MaaS subscriptions may also need to be developed post-COVID to accommodate

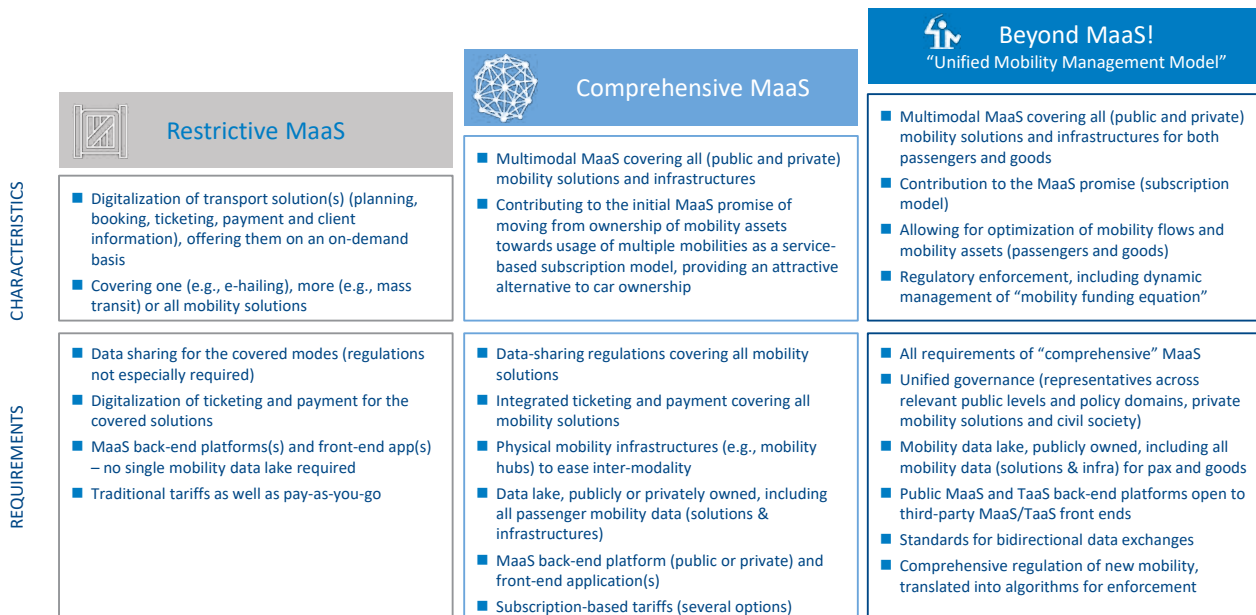
the evolution of increasing WFH, as well as the risks and uncertainties associated with possible interruptions in the case of new lockdowns or another crisis.

4.3 The requirements for achieving the potential of MaaS post-COVID – Moving towards a Unified Mobility Management Model

Today penetration of MaaS in its comprehensive interpretation, covering all mobility in cities and based on a subscription model (see Figure 10), is still very limited. Aside from the fact that comprehensive MaaS deployment in cities worldwide is still limited to a few cities, other basic requirements that would enable the success of comprehensive MaaS offerings are currently still missing in most cities:

- Clear **data-sharing regulations** covering all mobility solutions, both public and private, to ensure that there is a level playing field as well as integrated ticketing and payment.
- The availability of a **mobility “data lake”**, including all mobility data in order to “optimize mobility flows in the system interest” through suitable algorithms. In order to encourage multiple MaaS front ends, which is desirable for reasons of customer choice, as well as competition and innovation, cities (or nations) should strive for one single data lake, which should be managed by a public body so that it is truly open and unified. A privately owned data lake is also theoretically possible if there is only one MaaS operator in a city, but if there is more than one operator in a given city this is more likely to cause management complexity (as data would then not be centralized in one single place), or it would require the development of a so-called “roaming ecosystem.”

Figure 10: Beyond MaaS towards a Unified Mobility Management Model



Source: Arthur D. Little Future of Mobility lab

- Physical mobility infrastructures (such as intermodal mobility hubs). The success of the MaaS concept does not rely on digital only – it is not just about digital platforms and apps. It also relies heavily for its attractiveness and feasibility on the level of maturity of, and integration between, physical mobility solutions and infrastructures.

In practice these requirements are hard to achieve and in the case of most cities there are still some major obstacles, for example:

- Lack of comprehensive governance across all authority levels allowing for the full optimization across all mobility assets.
- Lack of a suitable data architecture to support the establishment of the required mobility data lake encompassing all modes and infrastructures across both passenger and goods mobility.
- No ability to implement an "enhanced mobility funding equation" allowing for trip-by-trip subsidy where the authority can signal through the pricing which trips are valuable to the system and thereby influence both supply and demand.

As we have indicated in the previous chapter (see game changer #3), the way to overcome these obstacles and achieve the potential of MaaS to foster more sustainable, resilient and human-centric mobility systems in a post-COVID world is to move towards a Unified Mobility Management Model. (See Figure 10.)

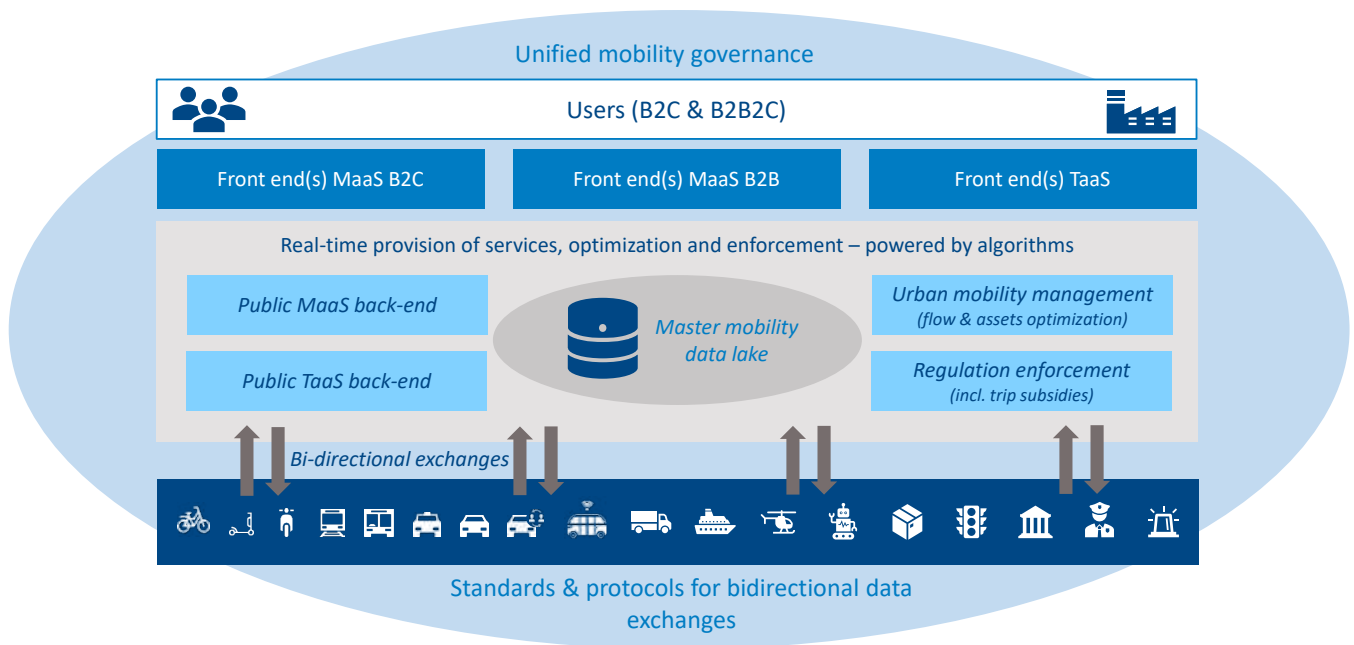
A Unified Mobility Management Model differs from a comprehensive MaaS model in four ways:

- The set-up of a multi-actor governance body, including involvement of government and authorities (across multiple mobility domains), public mobility players, private mobility players and user representatives.
- The ability to cover both passenger and goods mobility.
- The ability to optimize both mobility flow and assets, including dynamic management of public space.
- The ability to dynamically manage enforcement and funding.

Data is the key for a unified management model. A robust, secure and transparent data infrastructure is required that can handle in real-time all mobility-related data, whether generated by moving or fixed parts of the mobility system, whether privately or publicly owned/operated, and whether shared or unshared. The components of such an infrastructure are illustrated in Figure 11.

The starting point for the model is to have in place **standards and protocols** to enable data exchange, for example code syntax for data sharing. Standards also need to set out clear principles for issues, such as ethical use of individual data sets, data security, and fairness in utilization of data, such that the data lake remains open to all and contributors benefit in return for the value they have provided. We see that on a global scale very few cities have succeeded so far in taking those steps, and those cities that have begun are still at an embryonic stage (for example, Los Angeles, Vienna and Milan).

Figure 11: Key components of the Unified Mobility Management Model



Source: Arthur D. Little Future of Mobility lab

The **middle layer** of the model should ensure real-time provision of services and management with empowerment of all actors, making maximal use of their respective capabilities and expertise. The role of this layer could be considered the “brain” of the model, processing all data and suggesting/taking decisions informed by suitable algorithms.

In the **MaaS/TaaS²⁵ back ends**, different mobility services are orchestrated, delivering a seamless experience to users (most commonly known as plan, book, pay, ticketing, information/tracking functionalities). These allow for optimization of mobility flows at system level in the interests of the user, as well as prioritization of modes in the interest of the system as a whole. This is sometimes referred to as “MaaS Gov API” (even if this is not limited to an API!), where both predictive and reactive algorithms can suggest (based on preference or habit) or impose rules on the back-end activity. For example, in anticipation of a major event in a city, alternative routings and mode availability could be imposed by the authority in order to avoid congestion, or temporary tariff adaptation could be applied in case of an unexpected event or crisis.

The ability to gather and process infrastructure, vehicle and environmental data through IoT networks will bring myriad possibilities to city traffic-control centers to improve overall mobility flows and allow individual operators to optimize their services. Authorities will be in a better position to enforce mobility-related regulations, to manage commercial relationships between the different actors involved (e.g., clearing and

compensation rules) and to optimize financial flows in relation to public services (e.g., incentives and subsidies). For example, applying subsidies to on-demand and shared mobility solutions that would complement mass transit by providing the first or last mile in less dense city areas. This also leads to the creation of monetization opportunities with automated enforcement (for example, parking, traffic rules, operational and safety requirements for new mobility solutions) that authorities could not previously afford due to high operating costs.

Along with developing a unified long term mobility vision and implementing system-level regulations ensuring the right supply mix and influencing behaviors (see game changer #1), the Unified Mobility Management Model promises to solve most of the mobility issues we face in the post-COVID world.

²⁵ Referring to Transport-as-a-Service applicable to goods mobility

5. Opportunities to evolve offerings and operating models for increased resilience

5.1 How can operators adapt commercial offerings to meet the needs of the post-COVID world?

As we have mentioned in Chapter 1, mass-transit operators have been hit with collapsing demand and revenues while public service obligations required services to be maintained. At the same time operating costs for both mass-transit operators and MSPs increased due to new hygiene and health measures. Looking ahead, profitability will continue to be challenged by reduced patronage affecting both farebox revenues and ancillary revenues from advertising, retail and property development.

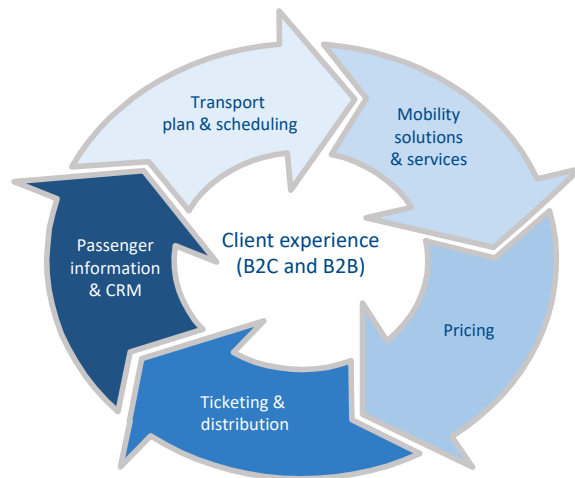
As well as seeking essential short-term cost reductions and improvements to staff and asset productivity, to move forward, MSPs now need to consider more pivotal and fundamental adaptations that can be made to their offerings and operating models. This is not only to align with changing needs and behaviors in the aftermath of the current crisis, but also to improve flexibility and resilience in the medium- and longer-term to withstand future crises.

Adaptation of commercial offerings by PTOS and MSPs during and in the aftermaths of the crisis is, in general, driven by two objectives:

- Improving the overall **customer experience** to support regaining trust, and to drive customer stickiness, preference and loyalty.
- Improving the **resilience** of the offering in the context of possible rapid fluctuations in demand in the future in case of future crisis.

Paradoxically, as a result of the fall in demand, travel conditions in terms of space and comfort will improve in the short term. Looking forward, however, all the PTOs in our study are continuing to make investments in improving the commercial offering (capacity and level of services) as a key lever to accelerate the recovery. These improvements stretch across a number of dimensions, as shown in Figure 12.

Figure 12: Key levers to recovery



In the following table we have provided an overview of adaptations to the commercial offering by PTOs/MSPs, either already taken during the crisis or that are being planned/accelerated as a result of the crisis.²⁶

²⁶ A new digital database was launched in June 2020 by a partnership of international NGOs and identifies global mobility responses to COVID-19, <https://www.covidmobilityworks.org/>

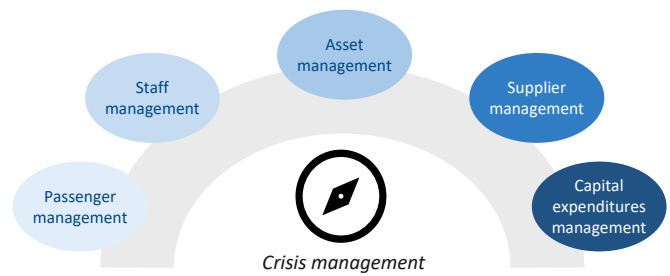
<p>Transport plan & scheduling</p>	<p>Review of timetables to ensure they still match the customer offer with a different demand spread.</p> <p>Flexibilization of the offer by distinguishing between the "core offer" and a "conditional offer" which can be injected in real time in case of additional demand.</p> <p>Development of database on loading of trains (reviewed on a weekly basis) allowing for "just in time" delivery of required service capacity, supported by data.</p> <p>Increased flexibility in planning to allow faster adaptation of the offer to the demand:</p> <ul style="list-style-type: none"> ■ Reduction of planning time. ■ Renegotiation of rules for staff scheduling to allow for more flexibility.
<p>Mobility solutions & services</p>	<p>Replacement of fixed public transport routes by on-demand public transport, e.g.:</p> <ul style="list-style-type: none"> ■ Connections between hotels and airports (Madrid). ■ Connections with hospitals, set-up of on-demand routes for essential workers. Value was justified by helping to separate flow of hospital workers from the rest of the public (Madrid, New York). ■ Transfer of disabled people in areas that are not connected. ■ Premium on-demand services for taking kids to school with taxi fleets, with taxi drivers vetted by police/administration (Shenzhen). <p>Replacement of traditional PT by on-demand solutions is expected to be accelerated, especially in the outskirts of cities where fixed routes are not efficient and where cost pressure is high. Such solutions are also enabled by the increased number of customers with smartphones and other digital devices.</p> <p>New services: development by hostels and restaurants of remote working spaces (in several cities).</p> <p>Product: "Homogenization" of the offer: provision of the peak-hour service level also outside of peak hours.</p> <p>Acceleration of the development of MaaS offering towards enterprise ("MaaS B2B") to trigger a change of behavior.</p>
<p>Pricing</p>	<p>Stimulate patronage growth/recovery from different segments through fare promotions & rewards.</p> <p>Flexible pricing of monthly passes and subscriptions to take stock of uncertainties in volume of travel (e.g., adaption to MaaS subscription pricing by MaaS Global).</p> <p>Incentivization of multi-modal trips whenever it makes most sense from a system perspective (triggering the use of shared and micro-mobility solutions as first- & last-mile in combination with mass transit).</p>
<p>Ticketing & distribution</p>	<p>Digital distribution and payment as a key contributor to regain trust and increase resilience of mass-transit systems. Acceleration of digitalization of ticketing and payment: QR code, Bluetooth, facial recognition, e-payment.</p> <p>Compulsory pre-booking of access to metro stations to avoid overcrowding.</p>
<p>Passenger information & CRM</p>	<p>Acceleration of plans to improve quality, timeliness and coverage of passenger information, including:</p> <ul style="list-style-type: none"> ■ Accelerated program (systems, channels, messages). ■ Real-time information on the level of charge. ■ Use of predictive data analytics to improve robustness and timeliness of information. ■ Use of chatbots to accelerate reach-out and treat volume. <p>Acceleration of MaaS development (as a way to improve multimodal passenger information).</p> <p>Integration of social distancing features in MaaS solutions. MaaS providers already offer travelers ways to know the current occupancy of certain modes of transport. Includes the ability to predict this in the near-term and to identify the best journeys based on customer preferences and prevailing conditions.</p> <p>"Virtual Seat" to help solve the major challenge facing public transit and rail operators to safely manage passenger volumes (e.g., adaptation to MaaS by IOMOB).</p> <p>"Mobility passport" leveraging multimodal routing algorithms for combined journeys, allowing a QR code that works for both modes of the journey (e.g., adaptation to MaaS by IOMOB).</p> <p>Improvement of passenger information on available bicycle lanes.</p> <p>Acceleration of investments in CRM and loyalty programs to drive customer preference and stickiness. Examples include providing information that is more specific to their needs & mobility patterns and opening up exchange and feedback channels.</p> <p>Acceleration of data analytics capabilities to increase understanding of new individual mobility patterns.</p> <p>Digital campaign (push on apps) on actions taken by mass transit and adaptation of the offering during the crisis, with information targeted to specific passenger needs.</p>

5.2 How can operators adapt their operating models to drive up cost flexibility and increase resilience?

Times of crisis are often a catalyst for innovation. Mobility is no exception, as PTAs, PTOs and MSPs need innovation to keep operations running while ensuring adequate sanitary conditions for passengers. In addition, failure is more commonly accepted in times of crisis; therefore, innovators receive generally more room for maneuvering to try out new things.

Over the past few months, many innovative initiatives have been introduced or accelerated, driven by the sense of urgency during the pandemic, mostly with the objective of increasing resilience of operations. The key question now is: which of those innovations will really have a lasting impact on speeding up recovery and increasing system resilience, and should therefore be continued in the post-COVID world?

Figure 13: Key levers to drive operational resilience



The table below provides an overview of adaptations made to the operating model during the pandemic, or that are being considered by PTOs and MSPs, to increase future resilience.

“It is critical to strengthen the offer while working to find a new economic balance for public transport, otherwise this will be at the expense of the quality of services for captive customers” [Mass-transit operator executive]

Crisis management	Business continuity management	Acceleration of the development of business continuity plans to increase the resilience of crisis management approaches.
	Health and hygiene committee	Set-up of a corporate health and hygiene (H&H) committee to oversee all H&H issues (higher frequency of meeting during the crisis).
	Rapid response process	Developing agile crisis management processes at system level, involving all key stakeholders (see also Box 4 below).
Passenger management	Information	Creation of new functions “transport ambassadors and enforcement officers” to ensure users of PT maintain safe distances and limit the numbers of users entering stations or buses (e.g., LTA Singapore). Development of crowdsourcing app to report passenger attendance numbers (e.g., RATP). Deployment of appropriate signage to encourage physical distance with the installation of stickers by field teams throughout the network.
	Prebooking	Compulsory prebooking of access to metro stations to avoid overcrowding (e.g., Beijing: booking of 30-minute slots to enter station).
	Reducing touch points with surfaces	Digitalization of stations towards contactless accessibility: touchless buttons (rolling-stock doors, elevators) to minimize touchpoints and use of speech recognition (AI based).
	Tracking compliance with mitigation measure	Mask wearing video detection (AI-based).
	Tracking of infected peoples	Identification of infected passengers through thermal scanners or face recognition, including further tracking, also via facial recognition or via a dedicated app.
	Limiting access to infected people	COVID-19 tracing systems connected to the citizen metro card, disabling its use in case of confirmed infection (e.g., Metro of Medellin).
	Detecting infections	Alternative use of rail-car or mobility infrastructure to transport, cure or detect infected people.
	Upgraded arrangements for crowd management (thereby reducing potential for contamination)	Use of crowd detection algorithms; model indicating when stations are overcrowded and actions to be taken (Partnership between ATM and Politecnico di Milano University). Upgraded CCTV systems and video analysis to monitor stations, stops and vehicles in real time to avoid crowding and manage passengers’ access. (e.g. ATM). Bluetooth Low Energy beacons in the stations to track passengers equipped with dedicated app in background and use of Wi-Fi/Bluetooth scanning devices in the stations and on-board vehicles to detect the amount of mobile phones (e.g. ATM).
	Staff management	Flexibilization of staff (schedules, tasks)

Staff management	Flexibilization of staff (schedules, tasks) (continued)	Set-up of backup teams to increase resilience in case staff members fall ill.
		Development of an AI-based staff planning process to increase flexibility through real-time demand and offer matching (e.g., Transport Lausanne).
		Shifting the role of controllers towards becoming client information agents.
		Deploy taxi drivers as transport ambassadors to monitor social distancing of passengers in stations.
		Several shared mobility MSPs have been using “rebalancing staff” to perform cleaning tasks.
		Use of ride-hailing drivers for last-mile delivery for logistics companies or restaurants.
	Automation	Further development of autonomous mobility (e.g., driverless metro) is also expected to build resilience as it minimizes staff contact with surfaces and other people.
	Training	Development of e-learning and communication platform, allowing training of and communication to staff via digital channels (e.g., training drivers and staff on new measures and behavior during COVID-19 period). Major cost saving is expected in terms of time and travel.
	Subcontracting	Increased usage of subcontracting for tasks such as cleaning to allow for more flexibility in terms of working time.
Asset management	Procurement of rolling stock	Adaptations in rolling-stock procurement, with smaller buses included to gain flexibility (for routing and for limiting “mass”).
	Spare-parts management	Increasing spare-parts inventory to mitigate the risk of lack of supply: negative impact on working-capital requirement; however, positive impact on maintenance regime due to increased spare-parts availabilities (considered to be maintained post-COVID).
	Cleaning/sanitation measures	Elevating the quality of cleaning in mass transit and shared mobility modes (“COVID-19 told us that we need to step up the hygiene level”).
		Introduction of new or enhanced cleaning and disinfection material, such as enhanced air ventilation and antiviral or self-cleaning material for high-touch surfaces:
		<ul style="list-style-type: none"> ■ Applying nano silver titanium coating to areas frequently touched by passengers at stations. ■ Bikes and e-scooters with self-cleaning handlebars (copper-infused handlebars for micro-mobility devices). ■ Nebulization disinfection process with spraying of 20 micron drops of virucidal products.
		Deploying automated processes and devices:
	<ul style="list-style-type: none"> ■ Automated escalator handrail-cleaning devices and vehicle disinfection which utilize ultraviolet (UV) light to kill nearly every germ. In vehicles, UV tubes automatically light up when no one is inside and stop on their own after the process is completed. Benefits include reduction of the time for disinfection (in Pudong: from 40 to 4 minutes), and cleaning all corners without the smell of bleach and conventional disinfectants. ■ “Vaporised Hydrogen Peroxide Robots” to conduct automated deep cleaning and decontamination in train compartments and stations. 	
Inspection teams auditing compliance with hygiene and health measures, and improvement of communications on health and hygiene issues.		
	Systematic disinfection of car sharing vehicles.	
	Urban logistics	Bus depot used as a warehouse for last-mile delivery of goods. Car park used as drive-thru for grocery delivery.
	Entertainment	Car park used as drive-in cinema.
Supplier management	Tendering process	Simplified tendering process during the crisis, allowing for reduced tendering time and more flexibility in contractual terms.
Capital expenditures management	Replanning of investments	Review of investment plans in light of expected reduction of funding.
	Prioritization of investments	Deprioritization of investments in road infrastructure, higher prioritization of investments in PT and shared mobility infrastructure.
		Adaptation of investment criteria to prioritize capacity improvement within current infrastructure (e.g., signaling) versus investments in network extension.
	Modularization of existing investment plans to give priority to investments positively impacting health and safety.	
	Financing model	Evolution of financing model: from cash investments towards leasing.

5.3 The way forward for operators to increase relevance and improve resilience

At a high level, the two key challenges for operators in the post-COVID world are around rebuilding customer relevance and trust and improving operational *resilience*. The ability of operators to meet both these challenges, and to further develop MaaS, depends hugely on further acceleration of *digitalization*. There are therefore the three “game changers” for operators.

Game changer #4: Build intimacy and proactively engage with clients

Key aspects include the following:

- Building better understanding of specific clients’ (B2C) needs, for example, using tools such as voice of the customer (VOC) and customer relations management (CRM).

- Improving passenger information (availability, relevance, reliability, timeliness, personalization).
- Proactively engaging with companies and schools to influence mobility patterns, complementing B2C by business-to-business-to-customer (B2B2C).

Communication and engagement with clients were a key issue during the crisis and continues to be so in the aftermath, in order to regain trust. The crisis has highlighted the need for both high-frequency and personalized communication with clients, based on a good understanding of their needs and their mobility behaviors. This increases the importance of having tools and channels to better understand customer needs, and to manage customer relations with refined segmentation to better tailor messaging. In the same way, the crisis has shown the importance of having efficient and personalized passenger information with good coverage and availability, relevant information, reliable, timely (low-latency time) and personalized.

“The COVID-19 crisis had a major impact on the openness of companies to review their mobility practices. There is an important window of opportunity for operators to complement their B2C product and services with a B2B2C offering”
[Mass-transit operator executive]

Companies and schools are also important, as well as individuals. The acquisition of a business or organization as a client is more cost effective than a single individual. The ability of an operator to proactively engage with these organizations could have a significant impact on mobility patterns and patronage, such as opportunities to adapt opening and closing hours to manage peak demand in a post-COVID world.

Game changer #5: Accelerate digitalization of both offerings and operations for preference and resilience

Key aspects include the following:

- Digitalization of **ticketing and payment** (including tariff integration).
- Digitalization of **passenger information**.
- Deployment of MaaS (B2C and B2B) front-end application(s) allowing users to conveniently plan their multi-modal journeys considering their preferences and prevailing circumstances.
- Digitalization of **operations**.

As described in our trends analysis, the acceleration of digitalization has emerged as a lever to improve resilience of operations (e.g., flexibilization of planning, automatization of

cleaning) and interaction with clients (digitalization of ticketing and payment, touchless buttons, QR codes, etc.). Further development of autonomous mobility (e.g., driverless metro) is also expected to build further in the longer term.

The crisis has shown the importance of speeding up the digitalization of the offer to allow, on the one hand, information in real time to avoid physical contact when traveling, and on the other hand to allow further intermodality in the pre-trip phase (plan, book, pay) and during the actual trip. These elements, in addition to the data-sharing aspects (see game changer #2), are critical elements for MaaS.

One of the important elements is the deployment of front-end MaaS (B2C/B2B), which allows different users to plan and anticipate their journeys taking into account their preferences, as well as prevailing circumstances (for example, specific selection of modes depending on a social distancing problem).

Game changer #6: Evolution of established crisis management approaches to better anticipate risks and improve resilience of operations

Key aspects include:

- Develop **forward looking risk management** approaches based on artificial intelligence and machine learning methods and supporting technologies.
- Develop **recovery scenario planning** and **business continuity** plans.
- Set up **crisis management and rapid response schemes** for increased agility and flexibility in planning and operation (e.g., reduction of planning and scheduling cycles, flexibilization of task allocation).

The COVID-19 crisis has provided a severe test of PTO resilience. Traditional static risk-register-based crisis management and business resilience approaches were typically found to be inadequate to match the pace and scale of the unfolding events. A more dynamic and **forward-looking risk management** approach based on “sense, feel and react” is key to improving the overall resilience of operations to future crisis events. New AI and ML technologies, coupled with high-performance computing and big data, can now provide the required data-handling and analytical power to make such an approach feasible, by improving forecasting and providing early warnings to dynamically define effective mitigation options and strategies.

Key aspects of the approach include:

- **Integrated risk analyses** using data from multiple internal and external sources and knowledge from in-house experts and specialists. Internal sources can include network,

fleet maintenance, staff, historical data on on-time arrival, information to traveler, pricing, ticket validation, etc. External sources can include data from other mobility solutions (e.g., traffic jams, level of occupancy of car parks, availability of MSP) and weather, service-level agreements and reporting from external providers.

- **Running in-depth “what-if” AI-based simulations**, for example, the impact of the variation of a single factor on the whole network (e.g., what if one specific park-and-ride car park is fully occupied before peak hour?).
- Understanding and drawing conclusions on the impact of the simulation (e.g., the need to set up a warning when the park and ride car park is 85 percent full two hours before peak hour, in order to provide proper real-time information to the traveler).
- **Automated responses**²⁷ such as standard operating procedures (SOPs) can be defined to run and handle the outcome of the simulation autonomously, in order to provide optimized responses such as injecting additional trains and buses. This has great potential for improving response times during all types of incidents, such as infrastructure or signaling system failures. For example, Singapore’s Land Transport Authority has implemented a similar data-driven analytics system to manage commuter traffic surges and emergencies.

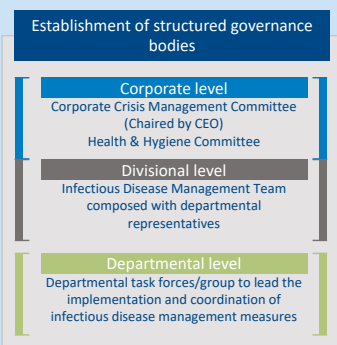
- Definition and understanding of the key risk indicators (KRIs) and associated tolerances that need to be monitored in a dashboard designed to support the decision-making process.

“The developments over the past weeks have highlighted the inappropriateness of traditional risk management processes and the need to develop more dynamic crisis management and forward-looking business resilience approaches to match the pace and scale of the unfolding events”
[Mass-transit operator executive]

Recovery scenario planning consists of identifying key macro uncertainties and defining a set of future potential realities in order to assess their impacts and prepare adequate strategic and operational responses. **Business continuity planning** allows for processes and ways of working to be readily adapted during the crisis to deliver required outcomes until the return to normal. Both are important aspects of improving resilience.

Box 5 illustrates some examples of effective **crisis management** and **business continuity management** by PTOs.

Box 5: Illustrations of crisis management and recovery scenario planning practices



Source: MTR

MTR acquired significant learnings from the SARS sanitary crisis that hit Hong Kong in 2003, and institutionalized new governance arrangements and processes to prepare for the next novel disease outbreak. In the aftermath of this crisis a health & hygiene committee (HHC) was installed, and rapid-response processes were put into place to provide a faster and more coordinated response across the organization.

A key consideration for governance was to get the right organization in place to cascade decisions with speed and efficiency. To that end, MTR established a structured governance and control architecture spanning the three main levels of the organization, allowing the right decisions to be taken at the right level from strategy to implementation.

During the COVID-19 crisis, the **Transport Public de Genève (tpg)** has used a proactive approach to rethink its commercial offering to match and take advantage of changing mobility patterns and behaviors. tpg analyzed four scenarios based on the magnitude of change of customer behaviors and restrictions on public transport. The four scenarios are: “Elastic behavior” scenario, with marginal impact on customer behavior and modal mix; “Eco-conscious” scenario, with shift to light modes of transport; “Shift-to-car” scenario and “Fearful attitude” scenario, with slow recovery and lack of trust in public transport.

tpg used recovery scenario planning as an input to evaluate the impact on its commercial offering through a systematic analysis of the required evolution of value proposition, interactions with key stakeholders and financial impacts on revenues and cost streams. These potential outcomes will be used either as short-term levers to accelerate post-COVID recovery or be integrated into tpg’s long-term strategic plan, “Cap 2030”.

6. How to move forward

6.1 The big picture for mobility in a post-COVID world

As we have seen, the COVID-19 crisis has caused a huge disruption to mobility systems, whose long-term impacts will depend a great deal on the duration and slope of the economic recovery and whether further crises will become part of the new normal. We have seen that the crisis has actually had the effect of potentially accelerating trends which already existed, such as changes in city topology, more e-commerce, more WFH and flexible working, increased health and safety requirements, healthier mobility modes, greater acceptance of new mobility forms and an increased need for more flexible, resilient and human-centric mobility solutions which depend heavily on digital technologies.

During the crisis, authorities certainly did not stand idly by. Many authorities took (or are currently planning) actions to frame and enable new mobility systems during and in the aftermath of the crisis. But not all authorities are equal in their ability and willingness to shape a fundamental change of paradigm in the aftermath of the crisis. Reflecting back on our exchanges with transport authorities in the study, we can broadly acknowledge that some two-thirds face significant obstacles.

However, the overall conclusion from the study is that the COVID-19 crisis, although it is a tragedy in terms of its health and economic impacts on millions of people, is also a unique window of opportunity for authorities and operators to significantly reshape mobility systems. They can do this by taking “no regret” actions to address established trends which will deliver major benefits, even if the recovery is fast and life does return to something like the pre-COVID world. This is infinitely preferable to overreacting and taking wrong decisions “in a moment of fear,” or conversely, doing as little as possible and gambling that the world will go back to the way it was before.

6.2 Insights for governments, authorities and mobility solution providers

In summary, we identified three no-regret “game changers” each for governments/authorities and solution providers to pave the way towards more sustainable, resilient and human-centric mobility systems, as summarized in Figure 14:

In the context of the huge uncertainty facing the world over the coming years, these game changers will not only help to shape and influence the future, but also provide an “insurance” against unexpected outcomes by improving system resilience. For city governments and authorities, we highlighted the need for a

Figure 14: Game changers to move towards more sustainable, resilient and human-centric mobility systems post-COVID



Source: Arthur D. Little Future of Mobility lab and UITP

balanced approach based not just on regulation (Framing), but also on enabling other system actors to move things forward coherently and effectively (Enabling).

Under Game changer #1 we specifically identified Framing and Enabling measures to **integrate “new” MSPs** so as to provide a “win-win” for both parties, including helping new MSPs to establish a viable financial model while ensuring they play their part in ensuring a resilient overall mobility system.

Finally, we identified under Game changer #3 the set-up of a **Unified Mobility Management Model** to deliver the full potential of a comprehensive MaaS, which will be the key for achieving flexibility, resilience and human centricity. A robust, secure and transparent data infrastructure is required to enable such a model.

6.3 Insights for other stakeholders

In order to deliver the new mobility systems we have outlined, concerted effort is needed by multiple stakeholders. We identified the following take-aways for other stakeholders:

Investors and private equity funds

- Collaborate further with public authorities to invest in the physical mobility infrastructure required to realize unified mobility systems.
- Factor post-COVID trends and the evolving needs of cities, citizens and local specifics into mobility investment assessments and decision-making .

Automobile OEM perspective

Cars will remain in our cities and contribute to the diversity of mobility offerings. However, pivotal adaptations will be required for actors to be part of the next era, including:

- “Doing differently, not more of the same” adapting their offerings while taking stock of the trends and the evolving needs of cities, citizens and the local specifics of their mobility systems.
- Bringing innovation to accelerate the transition to sustainable mobility, taking stock of the new balance of power for sharing of public space, and the evolving needs of cities and citizens.
- Shifting the relationship with cities and authorities by further collaborating on technology know-how as part of the broader mobility system.
- Taking new roles in the value chain by investing into components of the Unified Mobility Management Model.

Other industries in the mobility supply chain

Take stock of the trends and the evolving needs of cities, citizens and the local specifics of their mobility systems:

- Reorient the innovation compass to pursue quality of life and health, not only speed and efficiency.
- Collaborate with public authorities on innovation, including technology and business models.
- Develop relevant capabilities and contribute to key technology development domains needed to realize comprehensive MaaS and unified mobility systems.

Enterprise and citizens

- Take part and actively engage with governments and authorities (directly or through associations) to contribute to shaping tomorrow’s cities and mobility systems, as well as sharing concerns.
- For enterprises, take advantage of evolving trends and MaaS development to provide employees with attractive and flexible mobility offerings.

6.4 Final considerations

The COVID-19 crisis has been, in many ways, a defining moment for mobility in cities. Amid the damage and disruption, it has shown, for the first time in practical terms, that mobility could actually be very different in the future. It has caused society to reflect and reassess its values and priorities in what could be a quite fundamental way, highlighting the importance of issues such as health, hygiene, the environment and home life, as well as speed, convenience and consumption.

Changing the basic paradigm of mobility systems is hugely challenging, and up to now, most cities and countries have struggled to make the sort of fundamental changes needed to move towards sustainable, resilient and human-centric urban mobility systems. Despite, or even because of, the economic stress that we will see over the coming years, now could be the time for stakeholders to act together to make it happen.

Transport authorities have a critical role to play to accelerate change by “framing” and “enabling” the mobility system. PTOs and MSPs also have an important role to play in reinventing their offerings and innovating to increase their relevance and resilience. For investors and other industries in the mobility supply chain, mobility is an interesting playing field with strong value creation potential. Achieving success will require vision, creativity, courage and entrepreneurship – but now could be our best opportunity for decades.

Arthur D. Little’s Future of Mobility lab

As the world’s first management consulting firm, Arthur D. Little has been at the forefront of innovation for more than 125 years. Arthur D. Little is acknowledged as a thought leader in linking strategy, innovation and transformation in technology-intensive and converging industries.

The Future of Mobility (FUM) lab, launched in 2010, is Arthur D. Little’s contribution to tackling the urban mobility challenge. With this lab, Arthur D. Little aims to support cities, as well as public and private actors, in shaping the extended mobility ecosystems of tomorrow and facilitating an open dialog between urban mobility stakeholders.

- Assessing urban mobility systems (maturity, performance and innovativeness) as input for policy development, tendering tactics development or go-to-market strategies.
- Performing due diligence of innovative business models and solutions.
- Supporting new mobility actors in defining the most appropriate go-to-market strategies.
- Developing business and operating models for mobility platforms, such as Mobility-as-a-Service and urban logistics schemes.

Figure 15: Arthur D. Little’s Future of Mobility lab – Anticipating the future since 2010



Arthur D. Little’s Future of Mobility lab gathers under the same roof cross-industry and cross-functional professionals to support governments, authorities, mobility solutions providers (public and private) and investors in shaping their roles in future mobility ecosystems, through:

- Performing foresight analysis and developing medium- to long-term mobility scenarios in uncertain environments.
- Advising governments and authorities on the definition of mobility vision, policies and roadmaps at national, regional or city level, preferably through a collaborative approach involving key public and private mobility stakeholders.

If you have specific enquiries or would like to arrange an informal discussion on new mobility issues and how they affect your business, please contact futuremobility.lab@adlittle.com. You can also access the latest publication of the Future of Mobility lab at www.adl.com/futuremobilitylab.

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The Future of Mobility post-COVID

Turning the crisis into an opportunity to accelerate towards more sustainable, resilient and human-centric urban mobility systems

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UITP

UITP (the International Association of Public Transport) is a passionate champion of sustainable urban mobility and is the only worldwide network to bring together all public transport stakeholders and all sustainable transport modes. We have more than 1,800 member companies coming from 100 countries. Our members are public transport authorities and operators, policy decision-makers, research institutes and the public transport supply and service industry.

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