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THE FUTURE OF MOBILITY 5.0

Changing gear in the journey toward sustainable mobility

ARTHUR D LITTLE

POLIS
CITIES AND REGIONS FOR TRANSPORT INNOVATION

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FOREWORD

We live in uncertain and unpredictable times, yet looking into the future remains a key component of leadership. What trends and challenges are affecting the evolution of our mobility systems? What new solutions should we be aware of, and which ones are actually able to deliver on their promises? How can public and private sector initiatives come together and mutually reinforce each other? What will change the game in the years to come?

This Report is the fifth in a series of comprehensive reports on the future of mobility since Arthur D. Little (ADL) originally set up its Future of Mobility Lab in 2010. It aims to shed light on what key stakeholders — transport authorities at local, regional, and national levels; public and private mobility services providers; transport sector suppliers; and investors — should do to shift gear and accelerate the transition toward more sustainable, resilient, safe, inclusive, efficient, and human-centric mobility systems (hereafter referred to as "virtuous mobility systems").

The primary audience for this study includes mobility leaders and decision makers from around the globe, including political decision makers, C-level executives, and management, as well as policy advisors. Given the breadth of our target audience, it is anticipated that some content may be familiar to certain readers while serving as new information to others. This diversity of knowledge is intentional, as the study aims to provide a holistic view of the critical components necessary for a virtuous mobility future. It also seeks to uncover common blind spots, encouraging a broader perspective that transcends familiar viewpoints.

For this edition, we joined forces with POLIS, Europe's leading network of local and regional authorities advancing sustainable mobility through transport innovation. Over the past months, we talked to many global private and public sector stakeholders, engaged with POLIS members in focus groups, launched a worldwide survey to collect insights from leaders in the mobility world, drew conclusions, and formulated recommendations.

The study adopts a 360-degree perspective on mobility matters, from local to supra-regional levels. After taking stock of current mobility performance and trends, we dive more deeply into eight solutions currently at the forefront, aiming to demystify and critically evaluate them. We also reflect on their likely overall impact if they were collectively implemented and identify 10 game changers that we believe are critical for mobility systems players to shift gear and accelerate progress.

We hope you enjoy reading the Report and that it will be informative for your further mobility endeavors.

Sincerely,

Francois-Joseph Van Audenhove
Managing Partner,
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EXECUTIVE SUMMARY

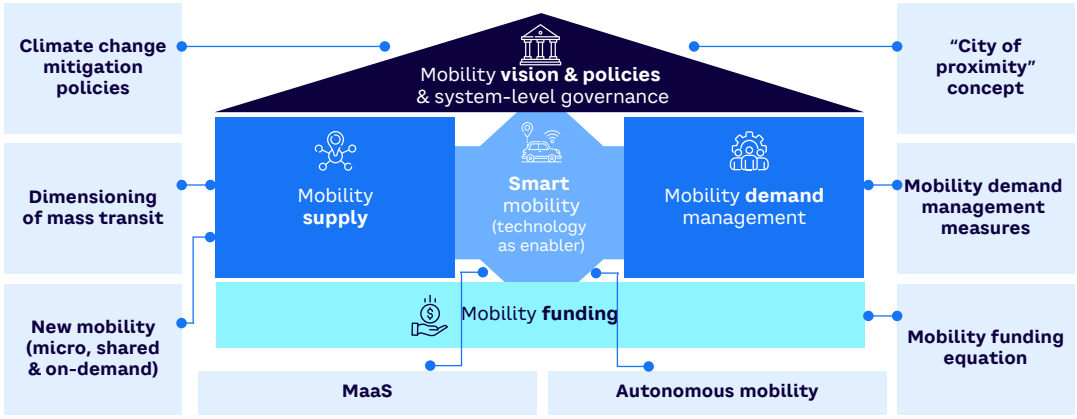
Progress toward the goal of more sustainable, resilient, safe, inclusive, efficient, and human-centric mobility systems in our cities has been slower than was expected a decade ago. While there has been some progress in the growth of public transport (PT) and active mobility (walking and cycling) — and new mobility devices and shared mobility services have been introduced — over the last 15 years the growth of these modes has been less than 10% globally, and individual cars still represent 70% of passenger-km (pax-km) in urban areas and 90% in rural areas. On a worldwide basis, transport still accounts for around 25%-40% of national carbon dioxide (CO2) emissions, the only sector with a steady increase since 1990.

On a more optimistic note, ADL's latest "Future of Automotive Mobility" global end-user study[1] found that between 42% and 72% of inhabitants in large cities of more than 250,000 persons would "perhaps" be willing to give up at least one of their cars if sufficient mobility alternatives were made available to them. Of course, there is often a significant gap between declared intention and actually taking action.

Over the last decades, the convergence of global trends has led to the development of new mobility services and business models with the promise of improving our mobility systems. These include personal mobility devices (e.g., e-scooters and other micromobility devices), shared mobility models, and autonomous mobility, as well as active mobility and the need for more integrated mobility services and information. To explore the impact of these trends, the challenges hindering their progress, and recommendations for overcoming them, the study undertook eight deep dives into promising solutions, including concepts, policies, and services (see Figure A).

Beginning with **mobility visions and policies,** there are still difficulties in adopting long-term, adequately integrated policies to secure real progress on climate change mitigation and the move toward net zero is still challenging. Mitigating climate change's impact requires a more joined-up policy approach, whereby electrification is complemented by a modal shift away from the private car to more sustainable modes as well as by transport demand reduction.

Figure A. Eight solutions reviewed as part of study



Source: Arthur D. Little

1 Parkin, Richard, and Phillip Seidel. "Future of Automotive Mobility, 2024." Arthur D. Little, forthcoming 2024 (based on survey conducted in Q4 2023).

Reshaping mobility behaviors also requires reshaping public spaces away from a century of car-centric transport policies and urban planning. Overall, the concept of the "city of proximity" has great potential to contribute to sustainable mobility. Going forward, city authorities should pursue efforts to deploy the concept but at a larger scale, with possible adaptations to cater to how digitalization has changed citizens' needs for proximity, and with a stronger emphasis on measuring systemic impacts.

Looking at **mobility supply,** authorities should become smarter with transport mode allocation through the development of multimodal transport masterplans that prioritize transport services according to their performance and affordability, including supporting the development of mass transit in its key role as the "backbone" of sustainable mobility as well as encouraging complementarity with other sustainable modes where these can be more efficient, convenient, and equitable. Authorities need to cultivate new mobility as part of the menu and foster partnerships with new mobility service providers (MSPs), rather than merely seek to regulate them. This also means that new MSPs need to take a greater interest in improving the ecosystem to maximize success and improve their economic and environmental viability.

In terms of **smart mobility,** mobility as a service (MaaS) needs to offer more added value functionalities beyond merely serving as an "umbrella" app for existing services. **In the long run,** we expect the benefits of autonomous mobility are not realized through individual automated vehicles, but rather through connected and mostly shared vehicles in smart traffic systems. **In the meantime,** the focus should be more on feasible use cases and applications, such as automated bus rapid transit (BRT) systems and automated bus driving in depots, rather **than going directly to** the moonshot of autonomous vehicles (AVs) in mixed traffic.

Mobility demand management (MDM) is crucial to enabling modal shift away from private cars. We identified some "sweet spots" among many possible demand management measures, including urban vehicle access regulations, specific infrastructure initiatives like intermodal mobility hubs, personal travel management measures such as smart parking solutions and MaaS apps, and marketing strategies that promote sustainable mobility.

THE SOLUTIONS NECESSARY FOR A TRANSFORMATIVE SHIFT ARE ALREADY WITHIN OUR GRASP

Finally, all measures mentioned above need significant additional **mobility financing.** Closing the funding gap will require more effective revenue management (e.g., through fare policies and subscription models), improving the attractiveness of public transport, and diversifying to secure new funding sources. On the expenditure side, transport authorities will need to better maximize the cost-effectiveness of capital investments and improve operational efficiency.

Our analysis leads us to conclude that, with comprehensive implementation, appropriate funding, and robust governance at the system level, **the high-impact solutions we have reviewed could potentially double the global share of sustainable mobility from approximately 30% to 60% of pax-km** within the next decade. However, none of the individual solutions has an impact of more than around 15%, so there are no shortcuts.

The solutions necessary for a transformative shift toward a more virtuous mobility future are already within our grasp. However, while the potential for transformation is evident, the real challenge lies in putting them into action. We identified 10 game changers that we believe are critical for mobility systems players to accelerate the transition (see Table 1).

Making change happen will demand political and organizational capacity as well as courage to change direction and determination to keep a steady course. Increased collaboration among public and private stakeholders within the extended mobility ecosystem is key. Transport authorities in cities and regions, in particular, play a crucial role in accelerating the shift.

Table 1. Game changers for more virtuous mobility

10 GAME CHANGERS			
Mobility vision & policies	1	**Combine "framing" and "enabling" measures for system-level mobility management**	• Local and regional authorities need to move beyond their foundational **framing** activities, such as putting in place a forward-looking mobility vision and suitable regulatory frameworks and policies, toward **enabling** activities (i.e., steering and orchestrating roadmaps to facilitate the implementation of solutions that necessitate a multi-stakeholder approach to foster acceleration toward achieving system-level sustainable policy objectives)
	2	**Adopt a more joined-up set of policies to secure progress on climate change mitigation policies "toward net zero"**	• Accelerate implementation of electrification strategy • Complement it with other net zero levers: modal shift and transport demand reduction to ensure that the overall impacts are maximized ("modal transition") and not limited to climate benefits alone
	3	**Reshape public spaces away from a century of car-centric transport policies**	• Progressively implement the "city of proximity" concept with larger scope, differentiated functions and a stronger emphasis on measuring systemic impacts
Mobility supply	4	**Develop a multimodal transport masterplan to better allocate transport modes, considering performance and affordability; invest in improved infrastructure for public transport, active and shared mobility**	• Focus on developing public transport as the backbone of sustainable mobility whenever traffic density justifies investments, including further development of existing mobility hubs and creation of new ones • Develop and encourage active mobility (walking, cycling) and micromobility services for trips under 5 km in urban, suburban and rural areas • Encourage shared and on-demand motorized mobility (car or motorbike sharing, taxis and ride hailing) for occasional longer-distance travel and in lower-density areas where mass transit investment is not the most energy- and economically efficient solution
	5	**Develop partnerships between authorities and new MSPs**	• Local and regional authorities need to cultivate new mobility as part of the menu of sustainable mobility services and foster collaboration rather than merely seek to regulate it • New MSPs need to look positively toward the "ecosystem play" together with transport authorities to maximize success and ensure their economic and environmental viability

10 GAME CHANGERS			
Smart mobility	6	**Embrace innovation and technology to better address user needs and operational/system requirements**	• Local and regional authorities need to steer and orchestrate roadmaps to enable implementation of solutions that require a multi-stakeholder approach, ensuring user- and policy-led deployment of technology rather than technology for its own sake
	7	**Frame and enable a virtuous mobility system "powered by MaaS" and anticipate AV development**	• Local and regional authorities need to adopt a comprehensive approach to frame and enable a virtuous mobility system "powered by MaaS" and anticipate future development of autonomous technology: – Taking ownership of overall roadmap for MaaS/AVs, adopting a comprehensive system-level approach – Actively financing and owning certain components, such as overarching integration layers, system-level data management and MSPs regulation enforcement – Getting ready for the future necessity of a "control tower" role in urban centers, which will be essential for real-time management of traffic flows and transportation assets • MaaS operators need to adapt their offerings to provide clearer value propositions that deliver on its real promise • Local and regional authorities, public transport operators and commercial MSPs must share information and services and work together for the greater good in an evolving open mobility ecosystem
Mobility demand management	8	**Bring about large-scale mobility behavior change through the right combination of demand management measures**	• Develop a comprehensive MDM strategy, considering a range of levers focusing on sweet spot measures with high impact and relatively low costs • Conduct effective marketing campaigns for virtuous mobility systems (mass transit, active and new mobility) with the right narratives and nudging tactics • Leverage corporates to foster sustainable mobility for their employees
Mobility funding	9	**Optimize effectiveness and efficiency of spending: value for money, money for result**	• Prioritize funding for the most efficient transport modes based on their usage rates and cost-effectiveness • Explore (partial) public funding of new mobility in areas where they enhance the overall mobility system and address public needs but may not be commercially viable • Commit to continuous improvement in management of PT operations (whether in-house or tendered) to identify new levers to optimize cost per passenger transported
	10	**Be proactive in exploring diversification of funding sources from both users and taxpayers**	• Local and regional authorities should coordinate policies for car regulation and development of public transport to optimize modal shift, ensuring social equity and optimized financing by internalizing external costs and capturing the value of public investment • Explore existing public sector loans at supranational level • Contemplate financial partnerships with investors to finance long-term development • Public transport operators need to explore smart revenue management

1. EXAMINATION OF CURRENT STATE OF MOBILITY SYSTEMS

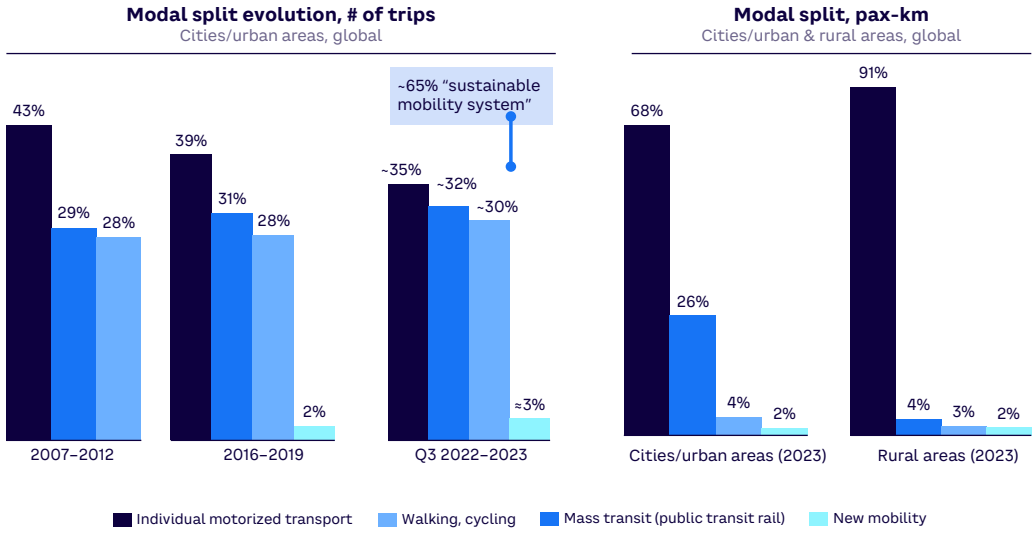
1.1 SETTING THE SCENE

When we first set up the Future of Mobility Lab in 2010, there was much optimism that by now we would have moved a long way toward the goal of more sustainable, resilient, safe, efficient, and human-centric mobility systems in our cities and regions. Technological developments — particularly in digitalization, connectivity, and automation — promised the ability to deliver tailored, diverse, and convenient mobility solutions that would be attractive enough to prompt a major shift away from private cars as the default mode.

Fourteen years on, things haven't happened the way many expected, though there has been some progress. In today's city centers, we have seen growth in public transport, active mobility (walking and cycling), and "new mobility" solutions, including shared and owned micromobility devices (e-bikes and e-scooters),car sharing, ride hailing, and electric-powered personal mobility devices (PMDs).

However, the bigger picture is less rosy. If we consider mass transit, walking/cycling, and shared mobility modes as collectively "sustainable," over the 15 years leading up to 2023, the share of these modes (in terms of trips) has only grown from **57%** to around **65%** globally, while the remaining **35%** of trips are still made by private car. And if we look at pax-km instead of trips, we see that private cars still represent about **70%** in urban areas and 90% in rural areas (see Figure 1), with strong discrepancies between Europe and Southeast Asia that have a stronger share of PT in the modal split on one hand, and North America and the Middle East where private cars is even more dominant.

Figure 1. Evolution of modal split (# trips) and % pax-km



Note: New mobility includes shared and micromobility (car sharing, bike sharing, e-scooter sharing, etc.); individual motorized transport includes taxi and ride-hailing; private mobility devices are not accounted for
Source: Arthur D. Little

If we look at commuting to work and school, it is clear that the private car is still hugely dominant. Our latest "Future of Mobility" survey of more than 16,200 respondents globally[2] confirms the trend: more than **70%** of citizens only use private cars for their daily commute, with only **14%** never using a car (see Figure 2).

Figure 2 also shows that the share of respondents who exclusively use other modes is very small, with **6%** using local public transport, **4%** using active modes, **1%** using taxis, **2%** using car shares, and 10% selecting "other." Moreover, the proportion of commuters who typically use modes of transportation other than private cars (including users of multiple mobility modes) ranges between 7% (for car sharing) and 17% (for local public transport).

If we look at how this varies between global regions (see Figure 3), there is even more individual car usage in the US (**78%**), but somewhat less in China (**61%**). China also has more use of local public transport, with **27%** using public transport together with at least one other mode. Over the last three to five years, globally the number of individual car trips increased by **34%** according to our survey, propelled especially by fast-growing economies (e.g., India, Vietnam, Thailand, and Mexico).

In the meantime, the global use of public transport showed a small decrease of a few percentage points. The use of active modes was stable globally, although it showed an increase of more than **10%** in Europe.

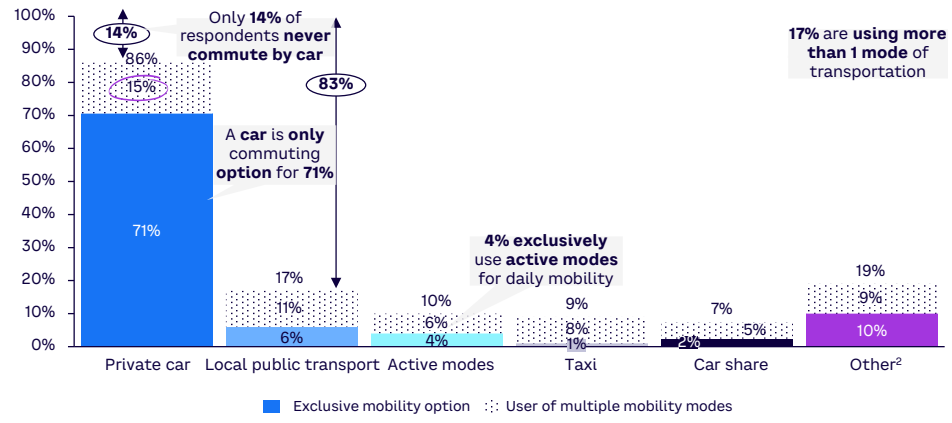
The lack of progress in terms of modal shift toward sustainable transport modes has negative impacts on transport:

- On a worldwide basis, transport still accounts for about **25%-40%** of national CO2 emissions, the only sector with a steady increase since 1990, according to the International Energy Agency (IEA).
- According to the International Transport Forum, transport still leads to a large number of casualties in cities: from **0.8** fatalities per 100,000 inhabitants in Stockholm to **7.4** in Bologna and **15** in New York City, with little to no change over past years.
- Despite less post-COVID traffic congestion, driven by increased working from home, levels have been growing again since 2023, and the average commuting time to work has not improved. In Europe, average time spent in traffic per year has risen from around 65 hours in 2019 to 90 hours in 2022, a rise of nearly **40%.**

In other words, at best we can talk of an **evolution** toward more sustainable mobility but certainly not a **revolution.**

Figure 2. Declared mode usage for daily commuting (work and school)

Question from Future of Mobility survey, 2023[1]
Please indicate which mode(s) of transportation you typically use for trips to and from home and work/school?

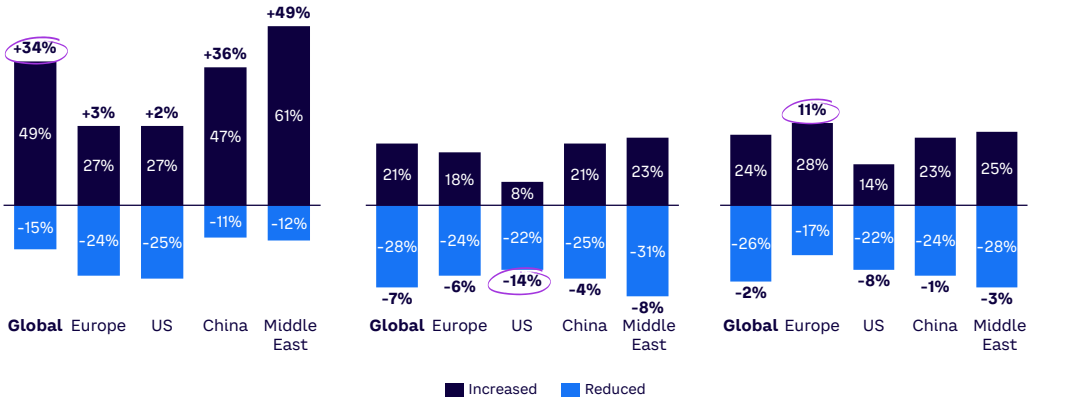


Note: (1) n=16,107; by design, the study includes 11% of respondents without a driver's license; (2) includes plane, long-distance bus, rail, car rental, etc.
Source: Arthur D. Little

2 "Future of Mobility Worldwide Survey (Q4 2023)." Arthur D. Little, forthcoming, 2024.

Figure 3. Declared mode usage for daily commuting (by geography)

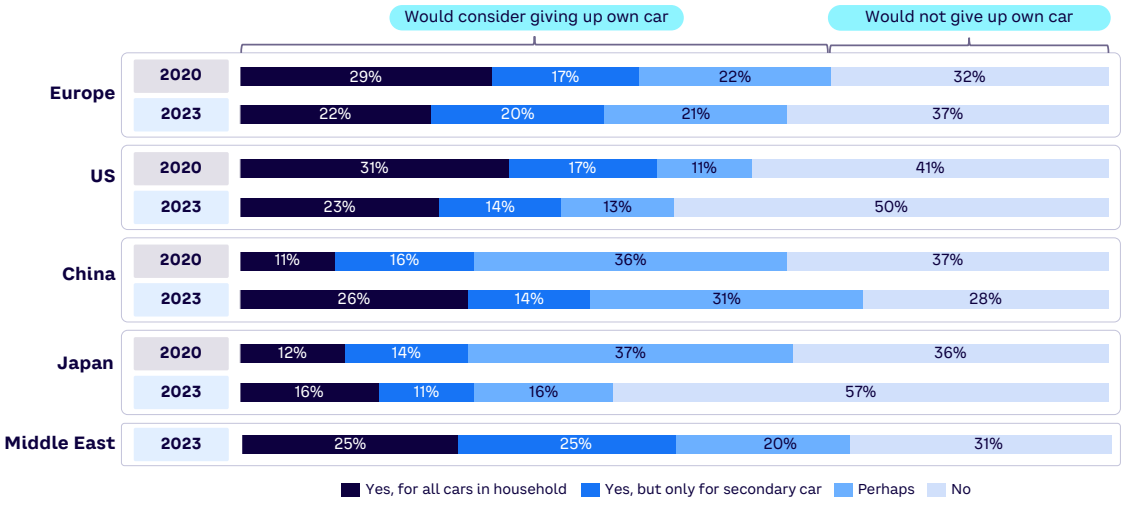
Question from Future of Mobility survey, 2023
How has your average number of trips per mode evolved over the last 3-5 years?



Source: Arthur D. Little

Figure 4. Willingness of citizens to forego (one of) their individual car(s)

Question from Future of Mobility survey, 2023
Given the new mobility and public transport services available today, would you consider giving up your own car? (applicable to inhabitants of cities with >250K inhabitants)



Note: Values weighted by population of markets included
Source: Arthur D. Little

1.2 THE EVOLUTION OF MOBILITY PATTERNS

While many aspects of mobility evolution can be reasonably seen as disappointing, there are positive indicators. Regarding individual car usage, a significant proportion of citizens would consider foregoing at least one private car if sufficient mobility alternatives were available. Figure 4 shows that between **27%** and **50%** of inhabitants in large cities of more than 250,000 would be willing to give up at least one car based on new mobility and PT services. A further **13%-31%** would "perhaps" give them up. This is a high number, although clearly there is a large gap between declaring an intention and taking action.

The geographical variation is also noteworthy: Asian and Middle East countries have a large share of citizens that may consider de-motorizing (e.g., **72%** in China and **70%** in Middle East), and this share is growing in Asia. In Europe, it accounts for about **63%** and less than **50%** in the US and Japan. One worrying trend is that willingness showed a decline between 2020 and 2023 in Europe and the US. There could be multiple explanations, but it can reflect a lack of confidence on the ability of mobility system to propose alternative services. It may also reveal that some people in developed economies who were willing to give up their secondary vehicle have already done so and are not ready to abandon the primary one.

The mobility providers themselves have an interesting perception. In a 2024 survey of 211 mobility leaders[3] (**85**% European) conducted by the BVA Family, ADL, and POLIS,[4] while **74**% rated recent progress toward sustainable mobility as at least "fairly satisfactory," the majority of them recognize the inability of those actions to deliver a sustainable modal shift, with **42**% judging the impact on modal shift to be "poor" or "very poor" and only **4**% rating the dynamics of the modal shift as "strong." On the positive side, looking forward, **73**% expected modal shift to increase either "moderately" or "strongly" in the next three years, reflecting some optimism within the industry. So, while there is little satisfaction with modal shift during past years, there is a widely shared belief within mobility CxOs that this will improve significantly in the coming years.

1.3 TRENDS & DEVELOPMENTS

We have seen a confluence of global trends that have been reshaping mobility systems over the last decades.

Global trends

- **Urbanization.** Approximately **55**% of the world's population live in urban areas, which is expected to further rise to **68**% by 2050,[5] in conjunction with growing urban-rural polarization.
- **Digitalization.** Around **two-thirds** of the world's population is now online, with over 50 countries having adoption rates above **90**%.[6]
- **Individualization.** Data ubiquity and digitalization of services have enabled increasing personalization of services, fueled even more by the advent of effective AI.
- **Sustainability.** Sustainability imperatives are now at the heart of public policy and corporate strategy, with inclusiveness and social responsibility also becoming imperatives. Issues such as emissions, air quality, noise, quality of public space, and safety are increasingly critical.

Behavioral trends influencing demand

- **"Everything as a service."** Often referred to specifically in relation to IT service provision, the broader trend away from goods to services has been ongoing for perhaps two decades. Consumers increasingly expect on-demand services such as e-commerce, which has a huge impact on urban logistics.
- **Shared economy.** There is continued growth in the involvement of consumers in crowd-based, peer-to-peer, collaborative, and/or community-based economies, often enabled by digitalization.
- **Green and healthy.** Consumer awareness of the need to behave in ways perceived as less environmentally damaging and better for personal health and well-being has increased, at least in developed economies.
- **Changing lifestyles.** Consumers, especially white-collar workers, are evolving their expectations around lifestyles and quality of life (e.g., work/life balance and flexibility).

Technology/market trends influencing supply

- **Connectivity.** Connectivity advances have continued to enable mobility service provisions, especially in relation to connected vehicles, consumer interfaces, and overall mobility system management (i.e., the mobility system "control tower" concept).
- **New sources of energy.** Electrification of mobility continues to meet sustainability requirements.
- **AI and autonomous vehicles.** Now and in the future, AI has significant potential to help solve many critical transportation and mobility challenges, improving effectiveness and efficiency and optimizing mobility performances at a system level.[7] We will also witness continuous progress toward the availability of AVs, albeit slower than initially announced by the main developers.
- **Speed.** There have been several attempts to develop innovative solutions to reduce travel time, make more efficient use of time while traveling, or avoid traveling altogether.

3 Mobility leaders and decision makers from around the globe, including political decision makers, C-level executives, and management as well as policy and technical advisors.
4 "Mobility Leaders 2024 Survey." Arthur D. Little/BVA Family/POLIS, forthcoming.
5 "World Cities Report 2022." United Nations Human Settlements Programme (UN-Habitat), 2022.
6 Kemp, Simon. "Digital 2023: Global Overview Report." Datareportal, 26 January 2023.
7 Majster, Michael, et al. "Artificial Intelligence in Mobility — Beyond the Hype, Where the True Value Lies." Arthur D. Little, June 2021.

The convergence of these trends has been reshaping mobility systems, leading to the development of new mobility services and business models that aim to improve the sustainability, resilience, safety, efficiency, inclusiveness, and human-centricity of mobility systems (see Figure 5).

For example, the convergence of demand for "everything as a service" and the availability of rapidly improving connectivity has driven the growth of personalized mobility services, such as on-demand mobility (ride-haling, ride-pooling) and MaaS. The willingness of consumers to engage in the shared economy has enabled shared mobility models, such as car sharing or carpooling, and is expected to also enable, later on, autonomous shuttles and robotaxis. Demand for green and healthy mobility along with the availability of new energy sources creates opportunities for active mobility devices as well as micromobility (e.g., bicycle, e-scooters, e-bikes, and other micromobility sharing). Finally, the combined availability of several of those solutions fuels the need for more integrated mobility services and information.

To summarize, today we see a mobility picture characterized by the increasing availability of new mobility solutions with a range of strong drivers both on the supply and demand sides. Yet, in terms of adoption, the progress has been significantly slower than was expected a decade ago, and modal shift away from private cars has been very limited. We are a long way from the goal of virtuous mobility system adoption.

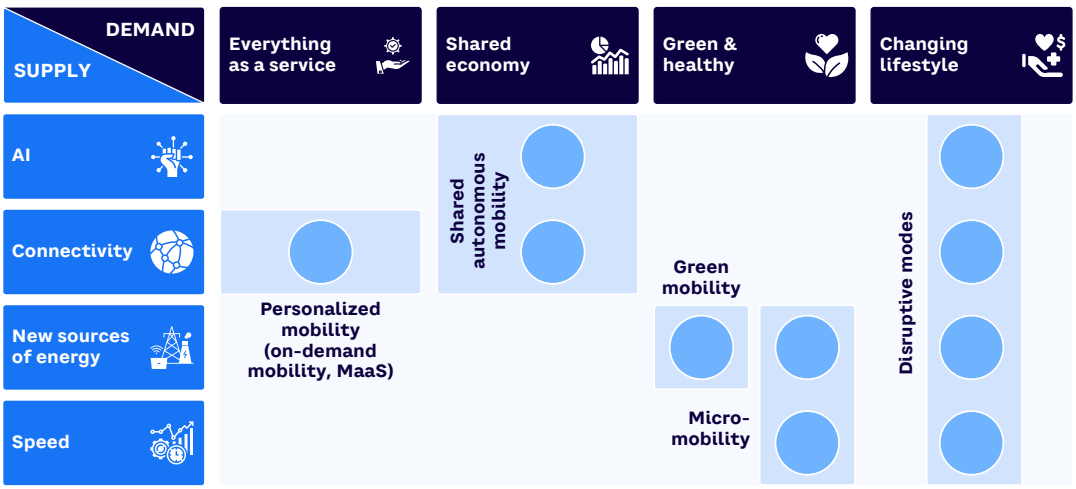
1.4 IMPACT & UNCERTAINTIES OF EXISTING SOLUTIONS

The lack of a "strong enough" business case is a key challenge for several of the new mobility solutions (micromobility, shared mobility, and integrated mobility). This is sometimes driven by a lack of market demand but also by increased regulations, which may be well justified but also incur additional costs for operators. Often, reliance on 100% private funding means the solution is not viable. In fact, the aforementioned CxO mobility survey also confirmed the perceived slow pace of progress and the lower-than-expected impact of micromobility and shared mobility on mobility system performance. However, the survey also showed increasing awareness of the need for change, triggered by both climate change and a growing realization of the need for the public sector and the private sector to work together.

Needless to say, there are no easy shortcuts to overcome these challenges. But what solutions have the potential to accelerate the move toward virtuous mobility systems, and from those, which ones can actually be delivered at scale?

In the remainder of this Report, we further explore the barriers, challenges, and strategies to accelerate progress.

Figure 5. How trends enable new mobility solutions and business models



Source: Arthur D. Little

THE CONVERGENCE OF GLOBAL TRENDS HAS LED TO THE DEVELOPMENT OF NEW SERVICES AND BUSINESS MODELS RESHAPING MOBILITY SYSTEMS

Looking across the full range of mobility solutions (concepts, policies, and services), we see that some have proven high-impact and others less so. We also see that some solutions are subject to more uncertainty than others in terms of how and whether they will be able to deliver an impact if they are implemented at scale (see Figure 6).

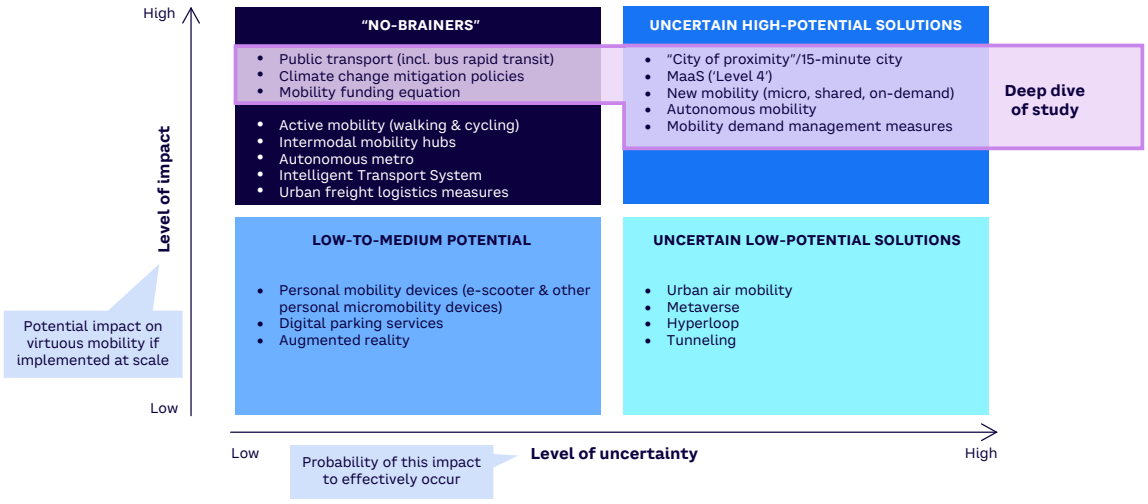
The bottom-left quadrant cites specific solutions that are fairly certain to be available, but their impact is limited relative to others, such as PMDs, digital parking services, charging infrastructure availability, and the use of augmented reality to assist the mobility journey.

Other solutions, which have relatively lower impact (often due to lack of scalability) and are more uncertain technically due to lack of maturity, include urban air mobility devices, metaverse applications, the hyperloop, and tunneling (bottom-right quadrant).

Looking at higher-impact solutions with lower levels of uncertainty (top-left quadrant) we see a range of "no-brainer" solutions that are key for the future, such as public transport, climate change mitigation policies, intermodal mobility hubs, active mobility, autonomous metros, intelligent transport systems (ITS), and urban logistics solutions. The major challenge of dealing with the mobility funding equation also falls under this category.

The top-right quadrant (high impact, high uncertainty) is especially important to gain a perspective on and better understand where we go from here. These solutions include demand and access management measures, city of proximity concepts, MaaS, new mobility (micromobility, shared mobility, and on-demand mobility services), and autonomous mobility.

Figure 6. Mobility solutions (concepts, policies, and services) and likely impact on modal shift



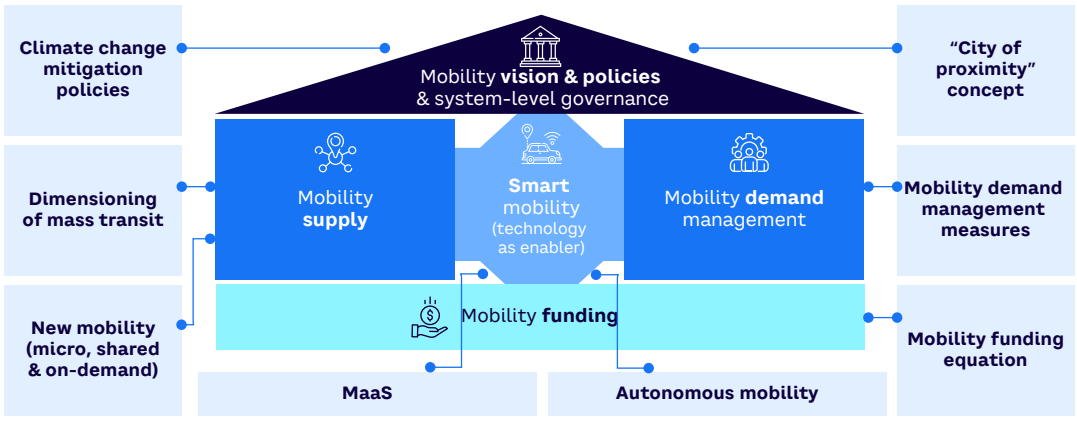
Source: Arthur D. Little

1.5 MOBILITY SOLUTIONS REVIEWED IN THIS STUDY

As part of the study, we undertook eight deep dives on promising solutions (concepts, policies, or services) to demystify and critically evaluate them, draw conclusions, and formulate recommendations. We have focused on three of the "no-brainer" solutions, namely **public transport,** for which there is still an open question regarding the extent of its future development, **climate change mitigation policies,** due to their importance and the difficult challenges of implementing them, and the **mobility funding equation,** which is a critical issue underpinning and enabling the ability to bring about change. The remainder of this Report focuses on the solutions in the top-right quadrant: **city of proximity**, **new mobility (micro, shared, and on-demand)**, **mobility as a service**, **autonomous mobility**, and **demand and access management measures.**

This gives us eight solutions, which have been mapped against the five-dimensional framework we traditionally use at ADL to describe the key building blocks of a virtuous mobility system[8] (see Figure 7). In this framework, the mobility system is guided by vision, policies, and governance. Supply and demand are both actively managed. Smart mobility acts as an enabler for the system, and adequate funding is made available through a range of mechanisms.

Figure 7. Eight solutions reviewed as part of study



Source: Arthur D. Little

8 This framework was first introduced in: "The Future of Mobility 2.0 — Imperatives to Shape Extended Mobility Ecosystems of Tomorrow." Arthur D. Little/International Association of Public Transport (UITP), January 2014.

2. DEEP DIVES ON MOBILITY SOLUTIONS

2.1 CLIMATE CHANGE MITIGATION POLICIES IN TRANSPORT

Context

As part of the world's essential infrastructure, mobility systems are deeply affected by climate change. Not only do mobility systems have to mitigate their impact by reducing greenhouse gas emissions, they also need to build resilience to adapt to new climate futures involving more extreme weather events and rising sea levels. In this chapter, we focus mainly on mitigation, although reference is also made to adaptation approaches.

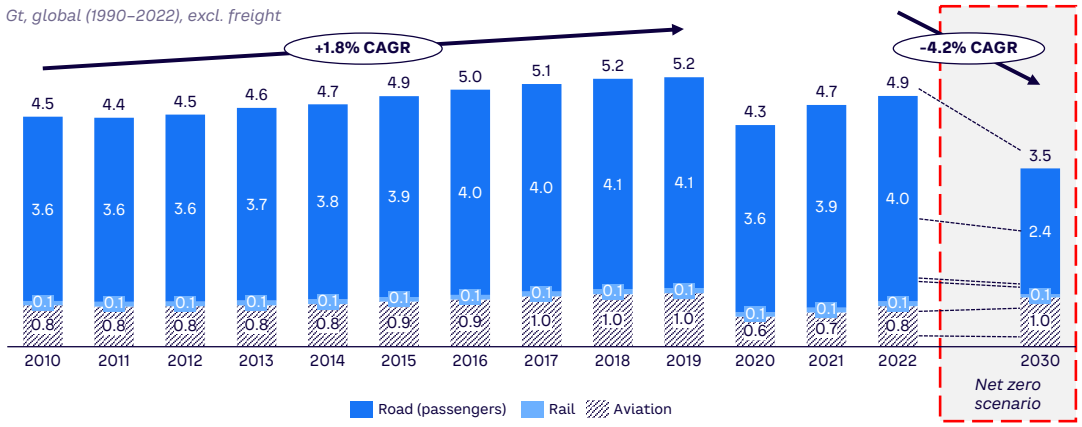
Inland mobility (i.e., excluding international road, air, and maritime mobility) accounts for more than a third of global CO2 emissions (according to IEA), a share that has been stable over at least the past 25 years.

In more than 80% of inland mobility, CO2 emissions[9] are related to road transport. However, the geographical pattern is highly variable. For example, in Europe, transport emissions have stabilized in most countries, including Germany, Spain, Italy, and the UK, while they are still increasing in countries within and beyond Europe, such as France, Poland, the US, China, India, and many others.

Several countries have set transport emission-reduction targets to achieve net zero by 2030, supported by legal frameworks and financial resources, but achieving the required reduction is likely to be difficult or impossible in most cases.

With regard to global emission-reduction targets, such as the achievement of net zero, transport is one of the only sectors where emissions have not decreased since 1990 (see Figure 8).

Figure 8. Public transport CO2 emissions for passengers



Source: Arthur D. Little, IEA

9 Excluding international road, air, and maritime mobility.

Challenges

Mitigation of climate change impact requires a more joined-up policy approach, whereby electrification is complemented by other key levers, in particular modal shift and transport demand reduction to ensure that the overall impacts are maximized (see Figure 9).

As shown in Figure 9, an effective transport emission strategy needs to focus on three levers (in order of **avoid-shift-improve**).

1. **Transport demand reduction.** Historically, the surge in car usage has been a primary contributor to increased emissions. However, the COVID-19 period demonstrated that significant changes are achievable with sufficient determination. Reducing demand can be accomplished by eliminating unnecessary trips, shortening travel distances, and employing behavioral change strategies. Restrictive measures for solo car driving can also be considered where other competitive options are available to expand the vehicle occupancy rate, which has been flat for around 40 years in Organisation for Economic Co-operation and Development (OECD) countries (e.g., in Europe, the vehicle occupancy rate has been 1.6 people per vehicle for many years).
2. **Modal shift.** This is about promoting a shift to less energy-intensive mobility modes by means of push and pull measures, away from private cars toward public mass transport, active mobility, and new mobility modes such as micromobility, shared mobility, and on-demand mobility.

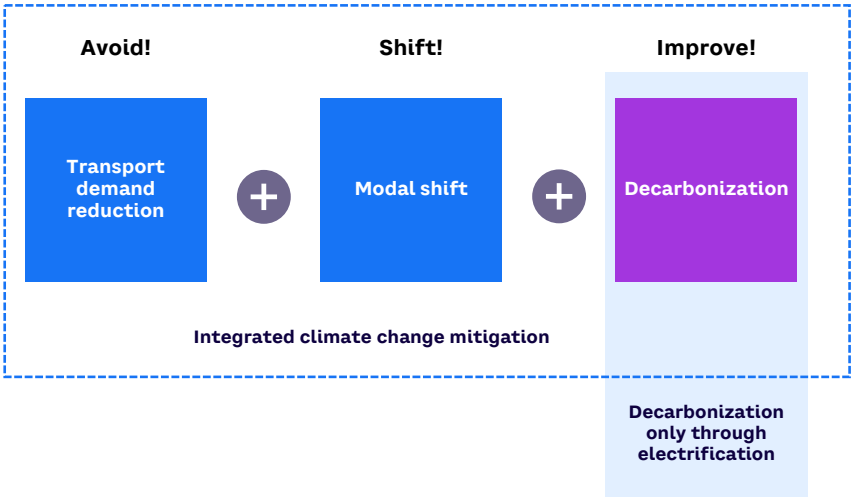
As individual car usage trends made clear, making progress has been difficult.

3. **Decarbonization through electrification.** This approach aims to achieve lower CO2 emissions thanks to electricity sourced from low-carbon sources (kg CO2/kWh), as well as better energy efficiency per km traveled (kWh/km). This can be only partially achieved over the short term with better internal combustion engine (ICE) fuel efficiency and use of alternative fuels including biofuels, as long as the potential negative impacts of crop-based biofuels (land use and food price increases, among others) are minimized.

These three routes to emissions reduction reveal two main difficulties impeding progress:

1. **There has been little real progress on transport demand reduction,** which is closely linked to economic growth and social cohesion, both of which are key political objectives.
2. **Current policy frameworks for transport emission mitigation tend to follow two partly conflicting paths.** One path is "decarbonization *only* through electrification," focusing mostly on improvement involving conversion of transport modes to renewable sources, such as cars and buses to battery electric vehicles (BEVs), trucks, trains, and planes to hydrogen, electricity, or biofuels, but with limited policies encouraging new mobility patterns. The other path is "integrated climate change mitigation" involving all three levers ("avoid," "shift," and "improve") to promote modal shifts away from cars.

Figure 9. Climate change mitigation strategies



Source: Arthur D. Little

These two policy approaches are increasingly in competition. Local and regional authorities are very sensitive to issues such as congestion and are keen to push the modal transition strategy; for example, large cities like London, New York, Madrid, Rome, Berlin, Amsterdam, and Stockholm all want to reduce private cars in urban mobility. Apart from reducing congestion and emissions, modal shift also provides opportunities to address other unwanted outcomes such as road crash fatalities and urban sprawl.

On the other hand, national governments are more divided on the strategy to follow, sometimes strongly favoring "decarbonization only," as cars provide significant economic benefits, in particular via tax revenues (fuel and road use taxes). Automotive may also be an important domestic industry that provides employment. But this is a narrow perspective; transport by private cars generates significant negative externalities, which come with an economic cost often not factored in, and the monopoly car transport holds on the space allocated to circulation and parking is blocking the emergence, consolidation, and growth of other transport solutions, which will also generate new business and create jobs. At the global level, modal shift has hardly made any progress. Cars remain by far the preferred mode due to convenience and practicality, especially in peri-urban and rural areas.

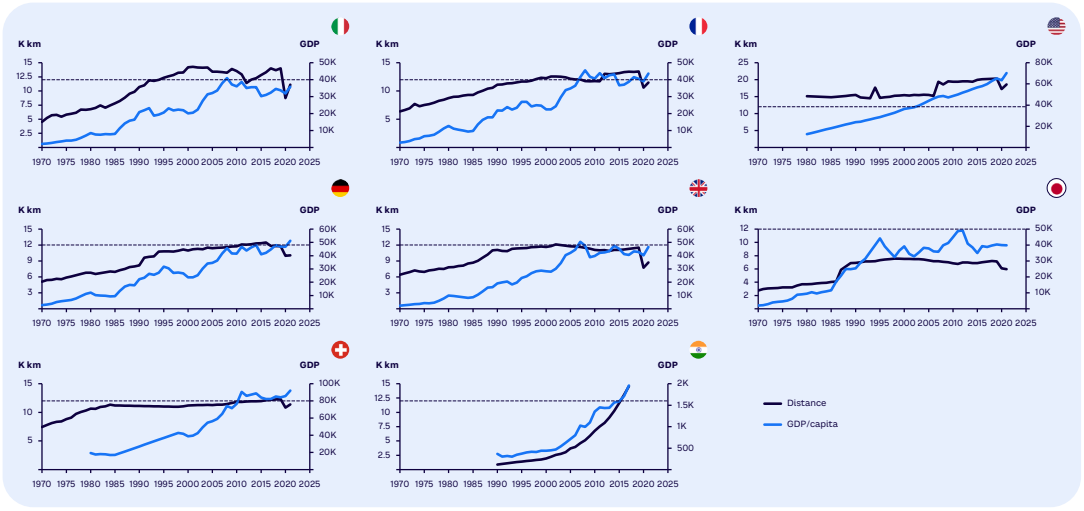
Analysis, insights & conclusions

Given the scale and number of these challenges, **what are the right policies and priorities going forward to ensure that the world's mobility systems can get on track to rapidly decrease emissions and increase climate resilience?** Based on ADL research and experience gained from POLIS, we offer the following insights into what should be done:

- **Almost no progress has been made in recent years to reduce overall transport demand.** Looking specifically at road transport demand in terms of total km traveled shows a correlation with social integration and economic development.[10] Hence, while the time assigned for daily mobility has remained stable over the last decades (45 minutes to 1 hour), the distance traveled has increased over the same period. This is due to two factors: (1) increased motorization of households due to wage growth and easier access to credit and (2) increased average car speed, in particular due to new motorways, peripheral streets, and ring roads.

  While road transport demand highly correlates to GDP per capita, our analysis revealed one fortunate trend: across major cities worldwide, it seems that we are now coming to a point where the annual average distance traveled per inhabitant has reached a ceiling of around 12,000 km (see Figure 10).

Figure 10. Average distance traveled/inhabitant in personal cars vs. GDP/capita



Source: Arthur D. Little, OECD, World Bank

10 Bigo, Aurélien. "Les Transports Face au Défi de la Transition Energétique. Explorations Entre Passé et Avenir, Technologie et Sobriété, Accélération et Ralentissement." Ph.D. diss., Institut Polytechnique de Paris, 23 November 2020.

The same 12,000 km ceiling is evident across most European countries. In larger countries such as the US, the ceiling is higher (around 18,000 km), but there are also signs of stabilization. If we are comfortable that neither the motorization rate per household nor average car speeds are expected to increase further, then in fact, a flattening curve is to be expected given a stable travel time.

Policies aimed at further reducing demand for road transport and distance traveled by private cars should thus focus on **reducing the need to travel** (to decrease the number of trips), **shortening ride distances** (to foster shorter trips), and **limiting travel speed** (to increase travel time) to reduce the attractiveness of road transport versus other mobility options while enhancing safety. Further progress on limiting car traffic could also be made through increased vehicle occupancy rates. This can be achieved by **penalizing or restricting solo car driving** and encouraging solutions such as **carpooling or ride sourcing.** While these solutions have not grown significantly over the last few years, there are good opportunities, especially in low-density areas for medium-size trips, for which the additional time associated with picking up an extra passenger is acceptable.

Some cities and regions have demonstrated success by applying constraints on car traffic, such as via urban tolls, limited traffic zones, higher parking fees, and fewer parking spaces. However, those constraints are inefficient without proper alternatives (e.g., better public transit networks) with both greater capacity and frequency, along with new mobility services (see Sections 2.3 and 2.4) and good active travel infrastructure.

- **Only limited progress is being made globally on modal shift.** At the country level, individual cars represent almost 80% of pax-km. In peri-urban and rural areas, the car remains by far the preferred mode for daily transportation, but only for those who can afford it, often creating what research has designated "forced car ownership," which includes extreme vulnerability to energy price fluctuations.

  Modal shift will improve only through a policy mix of constraints on cars and enhanced PT infrastructure and new mobility services (see Sections 2.3 and 2.4).

- **Good progress has been made on decarbonization through electrification.** However, the journey is long. For example, vehicle propulsion has benefited both from more effective ICEs and the adoption of other clean fuels, such as gas and hydrogen. In parallel, there are ambitious goals for the development of EV charging infrastructure and for incentivizing BEVs. The transition is also underway for PT emissions. On urban buses, transport authorities are benefiting from the need for tender renewal to ask operators to introduce new green fleets, while a long-term strategy has been adopted in some networks. Nevertheless, in Europe, on interurban and scholar coach services, less than 5% of the fleet is electric, mostly due to a lack of suitable offers from non-Asian vehicle OEMs, while public transit authorities (PTAs) often see public procurement as a lever to support local industry.

  Some issues are limiting the impact of electrification. First, the transition is slow due to replacement cycles (often, cars have a lifetime of 10-15 years). Second, the up-front costs of shifting to EVs for households and companies are still high, and there is limited willingness to pay the premium, especially given the uneven rollout of charging infrastructure and the perceived complexity of its use, as well as range anxiety associated with BEVs. Electric cars themselves also have an important carbon footprint due to the need to import critical raw materials used for battery production and non-repairable batteries, and some of the benefits are offset by the automotive industry's marketing preference for heavier vehicles, such as SUVs, which have reached 1 billion tons CO2 worldwide in 2023.[11]

11 Cozzi, Laura, et al. "As Their Sales Continue to Rise, SUVs' Global CO2 Emissions Are Nearing 1 Billion Tonnes." IEA, 27 February 2023.

With regard to charging infrastructure, challenges also arise from the grid capacity needed to support an increasing number of BEVs. Strengthening the resilience of electricity distribution systems, promoting efficiency, and facilitating the integration of clean and renewable energy are critical. In this context, solutions like smart charging and vehicle-to-grid (V2G/V2x) technologies will be crucial. However, strategic planning and collaborative efforts among public authorities, charge point operators, and grid operators are essential to address these challenges effectively.

Recommendations

Given the extent of what needs to be done, prioritizing actions and investment is critical to maximize the impact of mitigation strategies. This requires defining short- and medium-term goals per type of journey (urban, peri-urban, radial), using results-oriented approaches and constantly measuring progress.

- **Local and regional authorities should clarify their climate change mitigation ambition and strategy for citizens; for example:**
  - Do we want an electrification strategy only or a modal transition strategy, or a combination?
  - What are the ambitions and budgets that policymakers, and ultimately citizens, have agreed to?
- **Accelerate electrification as a key driver for decarbonization:**
  - Incentivize electrification of private cars, company fleets, and shared mobility, especially in areas where sustainable alternative options are defaulting.
  - Subsidize public transport operators (PTOs) in order to accelerate the pace of fleet electrification while concurrently growing their fleets and improving their services.

PRIORITIZING ACTIONS AND INVESTMENT IS CRITICAL TO MAXIMIZE THE IMPACT OF MITIGATION STRATEGIES

- **Introduce targeted measures to accelerate modal shift and reduce road transport demand:**
  - Leverage the city-of-proximity concept (see Section 2.2).
  - Improve PT attractiveness to trigger a modal shift (e.g., commercial speed) in suburban and peri-urban areas, where public transport competes with individual cars.
  - Introduce constraint-based policies to reduce the speed of motorized traffic, particularly passenger cars, and limit travel speed for car users, which will lengthen travel time, thereby reducing the attractiveness of private cars and fostering modal shift (see Section 2.7).
  - Restrict solo car driving within urban areas where other competitive options are available.
  - Introduce targeted subsidies to support sustainable modal shift. Many possible subsidy options can be considered. Using effective KPIs such as “cost of CO2 avoidance” can help to prioritize options.
  - Given the trend toward SUVs and heavy vehicles, use energy consumption (kWh/km traveled), vehicle size, and vehicle weight as additional metrics to encourage smaller personal vehicles, and avoid direct or indirect subsidization of heavier, more expensive, more dangerous, and less energy-efficient SUVs and other higher-end hybrid and electric passenger cars.
  - Invest in marketing and communications tools to boost modal transition, through nudging or communicating the impacts of mobility on health.

Climate change adaptation & resilience building

Transport infrastructures worldwide are suffering increasingly frequent and severe impacts from extreme weather events, which can have significant consequences, particularly in poorer and less developed regions. Hundreds of billions in financial losses are being attributed to flooding, extreme temperatures, and high winds. In 2023, Hong Kong's modern and highly reliable metro system suffered unprecedented flooding following record rainfall that the surrounding urban drainage systems were unable to accommodate, despite existing anti-flooding design features. In January 2024, major storms caused flooding in 200 subway stations in New York City, which represented nearly half the stations throughout the system. In comparison, only 88 stations were impacted by flooding in 2023. In the UK, the railways set blanket speed restrictions to mitigate the impacts of heavy rain and gale-force winds, leading to significant and frequent disruption to journeys.

High summer temperatures are increasingly causing disruptions as railheads weaken or deform, a noted risk in Sweden, Canada, and China. Rolling stock is often not designed to deal with excessive summer temperatures.

Hot conditions are especially difficult for underground metros; many trains and buses lack air-conditioning. The key challenge for mobility systems is strengthening the resilience of their infrastructures, which is essential to maintaining economic and social well-being in a climate-changing world.

Many transport system networks were simply not built to cope with current weather conditions. The costs to upgrade are typically billions at a national level. For example, in the UK, Network Rail has earmarked £2.8 billion over five years but recognizes that this may be the tip of the iceberg. Lisbon's drainage master plan, covering the years 2016–2030, with a total value of investment of €250 million over 15 years, is another example of the costs associated with climate adaptation policies at a local level.

Incorporating resilience into newly built systems is also costly, and it can be difficult to decide specifically what is needed and how far to go with hardening the infrastructure. Possibilities include high-/low-temperature resilience, flood prevention, vegetation management, overhead power line systems, ground works, sea defenses, and so on.

National governments have a substantial role to play here, as usually the market will not be able to support the investments needed. The EU recently introduced the Resilience of Critical Entities directive (2022/2557), which requires all EU member states to have strategies to enhance the resilience of their critical entities. The directive, which transposes into a law across all the member states in October 2024, was pushed by the EU Commission in response to a growing set of challenges, including extreme weather, and its impact on the lifespan of infrastructure and critical assets.

Technology also plays a key role in improving operational resilience. Together with the deployment of Internet of Things sensors for asset conditions, AI provides the opportunity to manage risks dynamically, enabling better prioritization of investment, better prediction of disruptions, and faster response. In Hong Kong, successful pilot trials have been conducted to enable better prediction of where severe climate events are most likely to cause disruption, through AI-based real-time analysis of weather data and tracking conditions. The UK has produced a risk-based tool that provides the railway with the ability to make better decisions about setting speed restrictions to optimize the impacts of disruption with safety risk.[1]

1 GUSTO Project, developed by Network Rail Wales & Western in collaboration with Arthur D. Little. This project was recently awarded a Railway Innovation Award by Modern Railways.

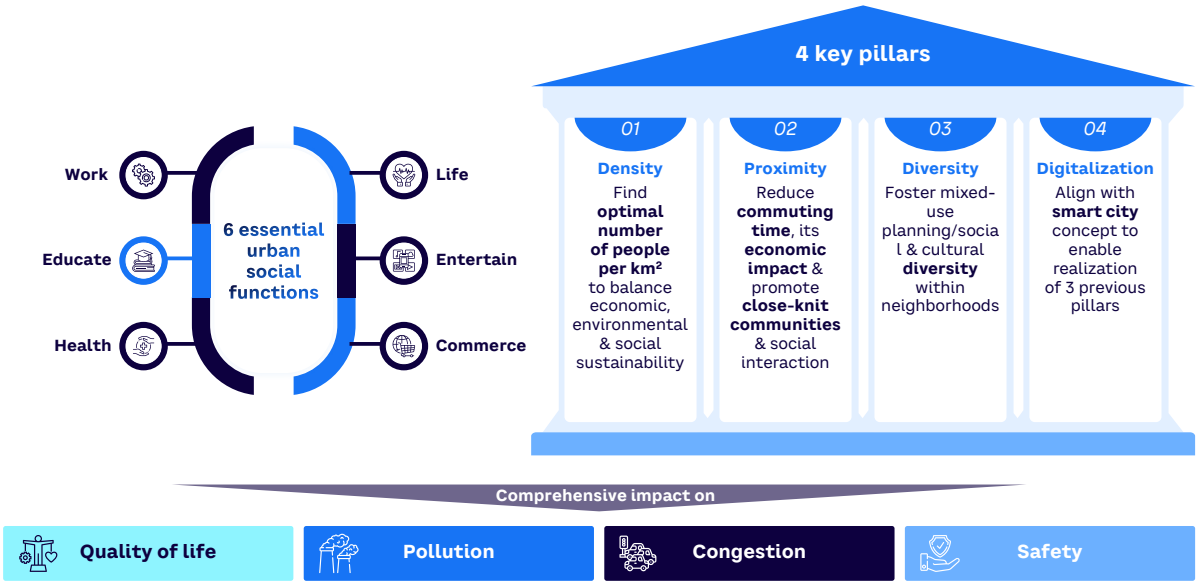
2.2 THE CITY OF PROXIMITY CONCEPT

Context

The city of proximity concept is an urban planning model that aims for more sustainable, livable, and healthier cities, by considering the closeness of services needed. Originating from the 1970s, when it started to replace "functional modernism" (i.e., building design should be based solely on purpose or function), the city of proximity concept has been increasing in importance, especially in the last decade. In 2016, French-Columbian researcher Carlos Moreno coined a new name for the idea, the "15-minute city," defining it as "an urban setup where locals can access all their essentials at distances that would not take them more than 15 minutes by foot or by bicycle." The concept is based around six essential social functions and four key design pillars (see Figure 11).

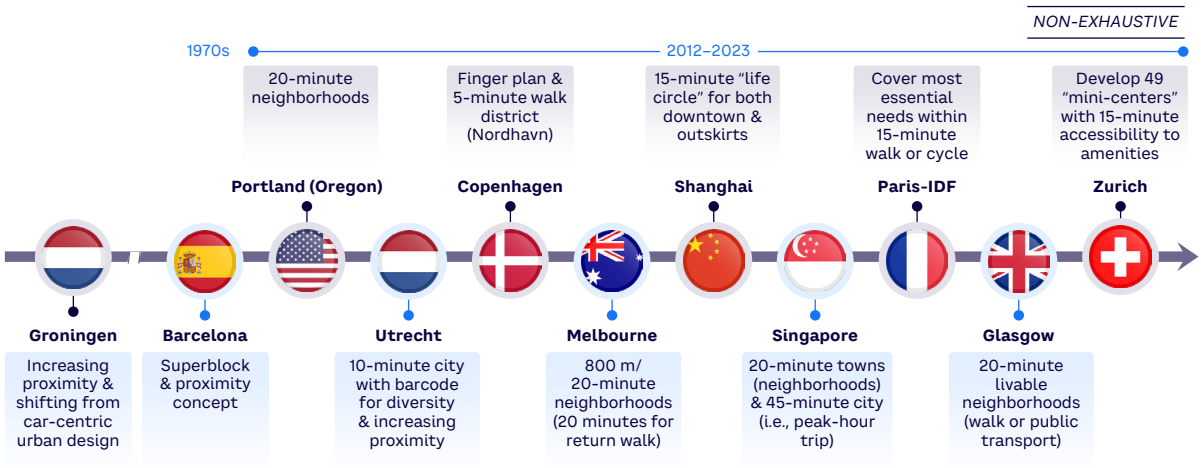
Multiple cities worldwide started giving a time reference to their city of proximity initiatives; for example, "20-minute neighborhoods" (Portland, Melbourne, Glasgow), "5-minute walk districts" (Copenhagen), "15-minute life circle" (Shanghai), and "ville du quart d'heure" (Paris). Beyond acting as a time reference, these cities aim to improve livability by ensuring the urban environment can respond to people's needs without the burden of lengthy trips and displacements. Today, the city of proximity concept is gaining increasing traction internationally (see Figure 12):

Figure 11. The 15-minute city concept



Source: Arthur D. Little, Moreno et al., European Road Transport Research Advisory Council (ERTRAC)

Figure 12. Examples of "city of proximity" initiatives



Source: Arthur D. Little

- The UN Intergovernmental Panel on Climate Change (IPCC) 2023 "AR6 Synthesis Report" considers "compact urban form" as one of the key opportunities for scaling up climate action.
- In 2022, the European research and innovation hub JPI Urban Europe started the "Driving Urban Transition" program, adopting "the 15-minute city transition pathway" as one of three key levers to tackle modern urban challenges.
- Also in 2022, C40 Cities, a global network of mayors of the world's leading cities created to fight the climate crisis, formed a partnership with UN-Habitat, real estate company Nrep, and Carlos Moreno and launched a new "Green and Thriving Neighborhoods program" to deliver proof of concept for 15-minute city policies.

The city of proximity concept holds the potential to transform and enhance the utilization of urban public spaces by adopting a people-centered approach. This shift begins at the micro level, including street design and neighborhood planning, and extends its influence to broader aspects of urban and regional planning, such as land use, housing policies, environmental and climate strategies, and mobility systems. Each element, though small-scale, is interdependent and significantly impacts the larger urban framework.

Challenges

Although the city of proximity concept is appealing to many stakeholders, it is much more difficult to implement in some contexts than in others. For example, it may not work well in suburban areas, low-density developments, historically monofunctional neighborhoods, or in old cities with very limited space for improving street design. Moreover, it can be difficult to measure the overall city-wide impact of what are normally local or neighborhood initiatives.

The 15-minute city concept already has image problems in some cities, like Glasgow, where it has been accused of locking in pockets of prosperity, excluding certain parts of the population, and reinforcing local areas of deprivation, arising mainly from misconceptions and conspiracy theories as to the concept's purpose.

IMPLEMENTING CITY OF PROXIMITY CONCEPTS REDUCES TRANSPORT DEMAND AND FAVORABLY IMPROVE MOBILITY EXTERNALITIES

The governance of city of proximity projects is often difficult, requiring extensive coordination among various stakeholders, including city authorities, transportation companies, real estate developers, local communities, commercial operators, and others.

Analysis, insights & conclusions

Given the current challenges, how sure are we that these increasingly popular city of proximity initiatives are really contributing to superior mobility system performance? To help answer the question, we studied eight cities currently implementing different variations of the concept: Barcelona, Groningen, Utrecht, Glasgow, Paris, Copenhagen, Singapore, and Portland. We gathered data through desktop research and interviews with representatives of urban planning and mobility authorities from several cities and engaged with a task force of academic researchers specializing in the topic. In particular, we focused on:

- What results have been achieved so far, and have mobility externalities (i.e., congestion, pollution, quality of life, and safety) improved?
- What are the key components of success?
- What needs to be done by different stakeholders to further improve?

Overall, the analysis shows that the eight selected cities implementing the city of proximity concept are generally performing favorably in terms of mobility externalities versus averages, both locally and for the city as a whole; for example:

- **Quality of life.** Based on an eight-criteria composite index,[12] quality of life ranks "very high" for five of the eight cities, with Barcelona and Singapore as "high" and Paris as "moderate."

12 Index includes purchasing power, safety, healthcare, climate, cost of living, property price to income ratio, traffic commute time, and pollution.

- **Pollution.** Six of the eight cities had average fine particulate levels between 5 and 11 µg/m3, versus a European average of 14.9 µg/m3. Paris and Barcelona were 14.7 and 17 µg/m3, respectively. Air quality indicators of all the cities fall in the "good" category.
- **Congestion.** With the exception of Paris, the selected cities perform well in terms of congestion, ranking between 98th and 273rd worst in the TomTom Traffic Index ranking, with average rush hour speeds between 27 and 38 km/hr. This may be compared with other cities like London and Milan, which are ranked 1st and 4th worst, with average speeds of 14 and 17 km/hours, respectively. Paris ranked 16th with an average speed of 18 km/hr.

TODAY THERE IS AN IMBALANCE IN THE RELATIVE LEVELS OF EFFORT

Even the bigger cities in the selection that inevitably have greater issues to manage reported **positive results** at neighborhood levels: Barcelona reported a reduction in local vehicle use of 82% following the creation of its Sant Antoni "superblock" (although neighboring streets saw an increase of 22%) and decreases of 25% and 17% in NO2 and particulate levels, respectively. Paris had improved quality of life by promoting cycling, resulting in an increase of bicycle use of 54% in 2018–2019 and a reduction in car trips by 5% in 2020 versus 2010.

Analysis of actions taken by the selected cities versus the four key pillars in Figure 11 (density, diversity, proximity, and digitalization) shows that all four are being addressed. This seems to be a key component of success. However, today there is an imbalance in the relative levels of effort:

- Priorities are shifting toward building **diversity and proximity:** 43% of all detected actions focused on reinforcing mixed land use, and 57% aimed to improve temporal proximity.
- Only 15% of actions are dedicated to **density,** and only 12% leverage **digitalization.**

The progress still to be made on digitalization in an urban context provides opportunities to redefine what the city of proximity concept means. If we look at the six essential social functions of the 15-minute concept, digitalization has made them all easier to achieve remotely:

- **Work.** Remote working has greatly increased post-COVID. For example, in the US more than **20%** of the workforce will work remotely by 2025 according to Upwork. Even when employers require office attendance, it is frequently only for part of the week (e.g., three days instead of five).
- **Educate.** In a 2023 Eurostat survey, **30%** of Internet users in the EU (age 16-74) reported taking an online course or using online learning materials in the previous three months, with an increasing trend.
- **Life.** Although physical space to live is always needed, increased working from home means that city center requirements for housing have changed.
- **Entertain.** Remote entertainment is growing fast. For example, according to *Forbes*, in 2024, **99%** of US households subscribe to at least one or more streaming services.
- **Health.** More than **43%** of primary medical care consultations were conducted via telehealth services in 2020 during the COVID-19 pandemic, and the global telehealth market size is predicted to grow at **24.3%** CAGR between 2024 and 2030.
- **E-commerce.** According to Shopify's "Global E-Commerce Sales Growth Report," annual global e-commerce sales are expected to increase by more than **60%** from 2021 to 2027. Eurostat reports that nearly **70%** of EU citizens aged 16-74 years bought or ordered goods or services online in 2023.

While the evolution of these functions may generally diminish the need to travel through cities, against this there are issues such as livability, inclusivity, and well-being that also need to be considered in deciding proximity needs. Moreover, the same trends act to increase urban logistics demands, which also need to be managed and accommodated proactively.

Recommendations

Based on the analysis, we propose three recommendations to improve the impact of the city of proximity concept on mobility system performance:

1. **Improve measurement systems** to better track the impact of the city of proximity on mobility externalities:
   - At the individual neighborhood level, monitor the pilot area and its surroundings to better understand the impacts beyond its boundaries.
   - Conduct 15-minute city pilots for the whole city, as opposed to just one or two neighborhoods. This will help test systemic impacts at a city level, which is important in selling the concept to citizens and businesses.
   - Consider the potential of tactical urbanism intervention (through quick-wins). In Barcelona, for example, the city started with punctual, small-scale interventions, such as changing street design in specific blocks (the superblocks) and greening inside block patios, already showing improvements and the potential for new social functions in those areas, then structured and framed this within the city's broader mobility and urban planning, looking into the promotion of active modes and other sustainable mobility infrastructures and promoting an urban polycentric structure.
2. **Make use of the concept in suburban areas** by combining the ideas of city of proximity and transit-oriented development.[13] This means organizing 15-minute cities more closely around existing suburban public transport hubs (if this hasn't happened yet) or, conversely, extending the public transport backbone to better serve areas with the potential to build a 15-minute city, leveraging on learnings from cities that implemented city of proximity concepts, such as Groningen, Paris-Ile-de-France, Singapore, Glasgow, Utrecht, and Barcelona.

   Moreover, exploring how new mobility services and MaaS could be developed together with urban planning and design in suburban areas might generate new possibilities for urban morphologies that could respond to different mobility needs while not compromising environmental and climate ambitions. The concept can also be extended to different time-scales and areas (e.g., "30-minute territories").
3. **Embrace digitalization** by developing more actively the "digital pillar" and, through this, improve digital accessibility to essentials to make the "x-minute city" easier to achieve and implement in practice; for example, this could include policies to support partial remote working, encourage e-commerce, and emphasize the digital component of social services such as health and education. While embracing digitalization, it is crucial to maintain a harmonious balance between digital and physical realms, acknowledging that certain facets of quality of life are inherently tied to the tangible world. Green and blue infrastructure, natural environments, and social interaction are vital to our well-being. It is essential to guard against an overemphasis on digitalization that could potentially eclipse these critical components of life quality, which should be afforded greater prominence in urban spaces.

Overall, the city of proximity concept is certainly a key contributor to mobility performance and is likely to remain an important aspect of urban development as long as its implementation challenges are properly addressed. The city of proximity should be considered from different scales (small-scale street level to large-scale region level) and reinforce the links of urban and mobility planning, where new and improved ways of allocating and designing public space are possible.

13 Transit-oriented development refers to urban development that maximizes the amount of residential, business, and leisure space within walking distance of public transport.

2.3 DIMENSIONING PUBLIC TRANSPORT

Context

Historically, public transport has been developed to address congestion generated by cars in dense urban areas. Cities and regions rely on five main PT service offerings:

1. Suburban rail (up to 1 million passengers/day)
2. Metro (more than 100,000 passengers/day)
3. Tram (20,000 passengers/day for modern trams)
4. Urban bus (approximately 2,000 passengers/day)
5. Bus rapid transit (15,000-80,000 passengers/day)

In large urban areas, PT systems rely on both a mass transit backbone (metro, tram, and suburban rail) together with lighter solutions such as buses. In addition, PT systems may be complemented by interurban coaches as well as more flexible solutions such as demand-responsive transit (DRT) services[14] to serve low-density areas.

Today globally, public transport accounts on average for **10%** of km traveled at the national level, around 4% in rural areas, and 26% in large cities and urban areas. However, there are big differences in PT usage and modal share in different city contexts:

- Public transport has a large modal share of **more than 50%** in inner cities (e.g., Singapore, Hong Kong, Paris, and London).
- In outer cities, lower density restricts PT usage, hence the overall modal share for large cities is **25%-30%.**
- For commuting to and from work or school, PT usage is context-dependent. For example, the car is dominant in most medium-sized cities. In large cities, PT often has a larger share for commuting into the city (e.g., **74%** for Paris) than for suburb-to-suburb commuting.

Commuting is at the heart of the value provided by public transport, often accounting for a large percentage of all trips. Yet public transport still has a fairly low modal share of commuting trips. The distance between home and the nearest PT stop appears to be the biggest driver of usage.

Challenges

There are several challenges to increasing the share of public transport in the modal split:

- There are often constraints on how and where the PT backbone infrastructure can be developed (physical integration in densely built environment, costs, etc.), especially in city centers.
- As cities grow radially, there is a growing need for better PT coverage in suburban and rural outskirts to provide alternative options to individual car usage for commuting. Yet, as we have seen, PT usage is highly dependent on the distance between home/destination and the nearest stop or station, which is typically increasing as we move further away from the city center.
- Public transport is not always the preferred customer choice, even when available.
- Traditional PT cannot be considered as the only option for virtuous mobility. Increasing usage of sustainable mobility therefore depends on intermodal and multimodal considerations as well.

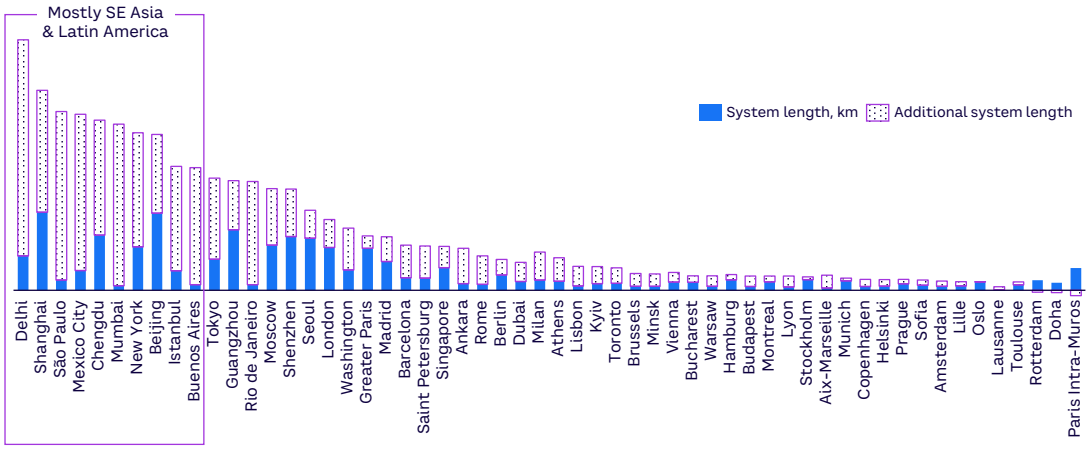
Analysis, insights & conclusions

With regard to developing the backbone PT infrastructure in cities, we explored the density of metro line coverage across the 80 cities that had metro networks in 2023. What is striking is that there is a huge variation in the metro network line length divided by the number of inhabitants, with mainly European cities such as Paris, Munich, and Rotterdam having the greatest infrastructure density. If we consider this an indication of the metro network length that could be theoretically added to bring cities to the same density levels, then the sky is the limit for some cities that could add hundreds of km of additional system length to their network (see Figure 13).

14 DRT refers to an on-demand bus service operated under public authorities.

Figure 13. Current metro system length (and theoretically additional system length) to reach greatest infrastructure density

2021, km; additional length to fit Top 10 km/inhab.



Source: Arthur D. Little

In theory, provided there is funding and political will, ample opportunities exist to extend the PT backbone in most cities. The Elizabeth Line in London and the Grand Paris Express in Paris are high-profile examples. Even if constraints are placed on the addition of new network length, there are substantial opportunities to improve metro capacity through technology, especially via full automation using communications-based train control (CBTC) systems.

Several different aspects need to be considered with regard to better suburban and rural coverage by public transport. Increasing PT traffic from suburbs to the center of urban areas is one challenge. Our analysis suggests that while the density of train stations is already high in some areas, there is much variability. For example, in Europe, Switzerland has 19.5 per 1,000 km2, Germany has 15.1, and France has 5.44. Therefore, as with metro networks, there is, in theory, still potential to build new stations to widen rail suburb-to-center coverage. Aside from heavy infrastructure development, BRT and DRT systems can also be favorable options.

The integration with other mobility modes is another key driver for increased PT usage in suburban and rural areas. This includes integration with bikes (e.g., in the Netherlands, 29% of rail traffic was combined with the use of bike parking in 2023); integration with "new mobility" services, such as micromobility, shared mobility, and on-demand mobility; as well as integration with private cars through the creation of park-and-ride (P+R) schemes.

Because public transport is not always the best mobility solution on its own, one important approach to improving the adoption of sustainable mobility modes is to be **smarter with transport mode allocation.** This can be accomplished through the development of multimodal transport masterplans, prioritizing transport services according to their performance and affordability, and better fostering complementarity and usage of different services within the transport system via intermodality ("intermodal trip") or multimodality ("multimodal life").

All prioritization strategies need to rely on a tailored analysis of the number of potential travelers as well as cost/pax-km, prioritizing the cheapest and most accessible mode to cover the maximum possible traffic and then going on to the next mode. The cheapest relevant mode will depend on various criteria, such as traffic density, traffic volume, and number of trips per class of distance. For example, while tram or metro could be the cheapest option in euros per pax-km for the core network in large cities, bus or bus-responsive transit will be better solutions in less dense cities. Similarly, as micromobility has a higher cost per passenger than public transport in dense areas, it is better suited for complementing PT in sparsely populated areas where it is less available or as a first- and last-mile solution combined with PT but not as a core solution in the city center.

Recognizing and accommodating the diverse needs of all users is also important, including providing paratransit options for individuals with disabilities, despite the potentially higher cost per passenger compared to standard solutions. It is crucial to ensure that the transport system is inclusive and accessible to everyone, reflecting the commitment to serve the entire community equitably.

As shown in Figure 14, in practice this means refocusing public transport as the backbone of the virtuous mobility system whenever traffic density justifies the investments (i.e., on longer journeys of more than, say, 5 km) and encouraging the usage of active and micromobility services for trips less than 5 km. This can help increase the load factor on buses/metros at almost the same cost. In this way, bike and walking infrastructure can be a key ally for public transport in the modal transition, enlarging PT coverage by reallocating capacity in the suburbs and cutting peak hour coverage. For the same reason, the usage of shared and on-demand motorized mobility like car sharing, taxi, and ride hailing should be encouraged for longer distance travel and in lower-density areas where investment in mass transit is not justified.

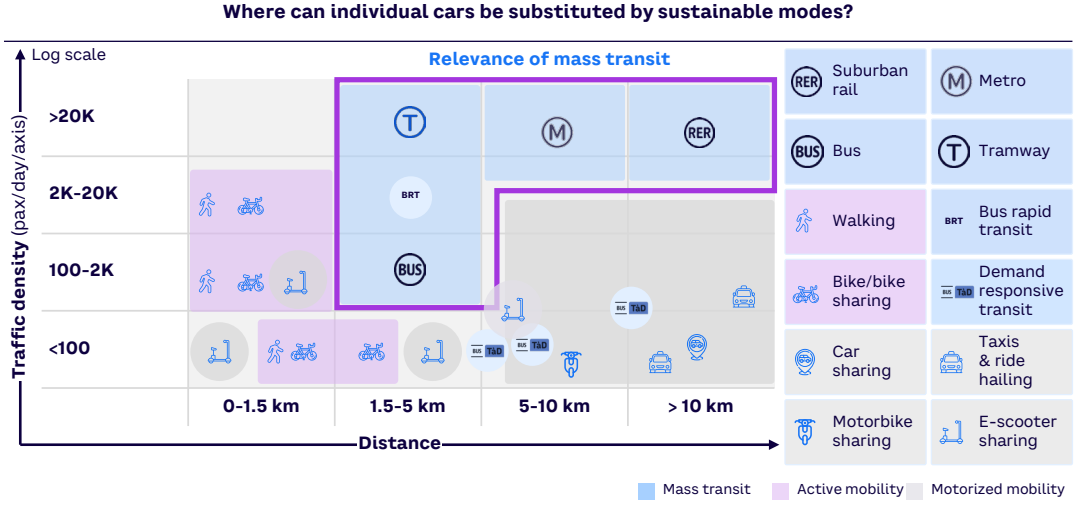
Recommendations

We offer the following recommendations for transport authorities and PTOs.

For local & regional authorities

- **Choose the right transport mode allocation:**
  - Upgrade the PT network with a primary focus on the backbone infrastructure and securing investment in mass transit to accompany urban development, ensuring that public transit networks can support growing populations and changing mobility patterns.
  - Then consider expanding surface modes (e.g., trams, buses, and BRT), focusing specifically on improving travel times and frequency.
  - Rely on active mobility where possible (depending on traffic, distance, and trip purpose) to enable reallocation of bus capacity outside of the city center.
  - Focus on trips to and from the suburbs with rail and urban transit integration.
- **Consider various strategies when extending coverage beyond the city center.** Expanding regular PT lines is a crucial approach but presents several challenges, including a lower pooling rate, which consequently increases the average cost per passenger across the entire network. Local and regional authorities should select the most effective options to mitigate high costs per pax-km.
  - Develop multimodal transport master plans at city, regional, and even national levels to optimize infrastructure and transport solutions usage via system logic and increase ease of use of the various networks collectively.

Figure 14. Prioritization of transport services according to performance and affordability



Source: Arthur D. Little

LOCAL AND REGIONAL AUTHORITIES SHOULD BE SMART WITH TRANSPORT MODE ALLOCATION CONSIDERING BOTH PERFORMANCE AND AFFORDABILITY

  - In that context, carefully investigate the pros and cons of subsidized DRT, shared mobility services, and private mobility devices (e.g., bikes and e-scooters).
  - When geographically expanding regular PT services, it is imperative to focus on enhancing the attractiveness of these services as part of the expansion strategy.
- **Foster integration of modes:**
  - Prioritize integration of fares, ticketing, passenger information, bike parking, and P+R.
  - Provide direction, guidance, and support to PTOs to open and integrate more toward new mobility solutions (see Section 2.7 on MaaS for more details on data openness and integration).

For PTOs

- **Maintain focus on quality of service to maximize attractiveness of PT as a viable option:**
  - Consider all aspects of quality of service, including service robustness, punctuality, accessibility, comfort, and simplicity of the customer journey (including passenger information, ticketing), as well as travel time competitiveness versus private cars.
- **Enhance multimodal (physical and digital) integration and intermodality:**
  - Address pain points associated with mode switching and developing mobility hubs to facilitate seamless transitions between different modes of transport.
  - Allow selective usage of PT infrastructure by new MSPs.
  - Integrate with new mobility services within MaaS (see Section 2.5).

2.4 NEW MOBILITY SERVICES: MICROMOBILITY, SHARED & ON-DEMAND

Context

New mobility is a diverse category that includes micromobility rental services (mostly bikes, e-bikes, or e-scooters), shared mobility rental services (car sharing and car pooling), and on-demand mobility services, including ride hailing and ride sharing).

It is important to distinguish between personally owned mobility devices and shared vehicles belonging to an MSP, which are the focus of our analysis in this Report. Whichever segmentation is used, the boundaries are constantly shifting as new services and vehicles are introduced, such as cargo bikes, micro-cars, mono-wheels, and e-skateboards.

Demand for micromobility and shared mobility continues to grow. For example, ridership in Europe increased by about **15%** in 2023 versus 2022, with growth especially in sectors like bike sharing (54% for dockless bikes and 13% for station-based bikes) and free-floating car sharing (54%), taking over the e-scooter market (growth of 3% only in 2023 while it led the market in 2019-22).[15] However, the share is still very small, representing less than 3% of trips in the modal split. It is noteworthy that services represent only a fraction of total micromobility trips and assets, with ownership gaining in popularity. For example, sharing services in France operate about 40,000 e-scooters, while an estimated 2.5 million belong to citizens. Sharing services are also often considered a gateway to ownership of personal mobility devices.

The industry landscape is evolving but in a largely predictable way. For example, the shared micromobility landscape is highly fragmented, with US-based companies playing a dominant role. Consolidation is already ongoing with multiple partnerships, mergers, and acquisitions making the headlines, such as Bird's acquisition of Spin (before ultimately filing for bankruptcy) and TIER's merger with Dott. This trend is not limited to two-wheelers with ShareNow and Free2Move joining forces in the car-sharing segment.

15 "European Shared Mobility Index Annual Review 2023." Fluctuo, May 2024.

MICROMOBILITY CATERS TO INTERMODAL TRIPS USE CASES, WHILE CAR SHARING CATERS TO MULTIMODAL LIFE USE CASES

Ride hailing and car sharing have already reached a fairly high degree of customer acceptance and are probably at the "early majority" stage. However, some two-wheeler services, especially e-scooter sharing, are still in between the early adopter and early majority stages. It could be argued that this format, used mainly by young men, may be stuck at this stage and may ultimately be replaced with other, yet-to-be-launched formats. In any case, effort is still required to extend micromobility usage to broader categories of users.

Shared micromobility services benefit from a relatively high demand and willingness to pay and are often used together with public transport to cater to door-to-door use cases (recently, several micromobility providers reported that more than 25% of their trips were intermodal with public transport).

There also is a demand for car-sharing and ride-hailing mobility services to support multimodal life use cases, which involve using different modes for different journeys and needs, both within and outside of cities. While some ride-hailing services seem to have reached a level of profitability, car sharing today generates low yield compared to ride hailing and micromobility, as it suffers from having a level of user willingness to pay that is not much higher than for micromobility and higher operational costs (e.g., maintenance, insurance, parking).[16]

Challenges

One of the key challenges of micromobility and shared mobility is that they are difficult to regulate compared to traditional mobility segments such as PT, cars, and bikes. Typically, micromobility and shared mobility developers and operators are entrepreneurial and technology-driven. They need, above all, to ensure financial viability, which often restricts their ability to prioritize societal concerns regarding the overall mobility system and urban planning. Moreover, the legacy of car domination makes new mobility regulation difficult. For example, scooters park on pavements because cars monopolize parking space, and scooters run on sidewalks because cars have a speed monopoly on roads. Car sharing and new delivery services are also constrained by the same legacy. Early on, this led transport authorities to focus too much on a "pest control" regulatory philosophy, rather than one that is strategic, proactive, and enabling for the overall mobility system, although this is already changing (see below). Another key concern is the economic viability of operators, with only a handful showing profitability. Excessive regulation increases operational complexity and cost for new mobility providers.

The safety of micromobility modes is a key issue for many, although, according to data from the International Transport Forum (ITF),[17] the situation is improving. The risk of casualties involving shared e-scooters in Europe is decreasing as their use grows more rapidly than injury reports. Up to 70% of total reported casualties are minor. Severe injuries account for a small fraction of total reported casualties, and fatal injuries from reported micromobility crashes constitute a relatively small percentage, up to 1% of total reported casualties. On the other hand, the overall safety of new mobility modes should always be a concern and requires transport authorities to set clear boundaries to mitigate risks.

16 For further considerations on the limitations of current car-sharing business models and imperatives for authorities and car-sharing operators to drive success, see: Van Audenhove, François-Joseph, et al. "Sharing in Success — How Car Sharing Can Deliver on Its Potential in an Ecosystem Play." Arthur D. Little/movmi/Mobility Cooperative, February 2024.
17 "Safer Micromobility." ITF, March 2024.

Analysis, insights & conclusions

Against this background, we conducted research and analysis to address the key question: **to what extent are micromobility and shared mobility solutions contributing to improving the mobility system?** Within this framework, we aimed to assess the current impact of new mobility on modal shift, the biggest pain points for new mobility service providers today, and what needs to be done by different stakeholders to further improve their positive impact toward more sustainable urban mobility systems. The work was based on quantitative and statistical analysis, desktop research, focus groups with mobility experts, and a primary survey of the mobility patterns of people around the world, involving some 15,600 respondents.[18]

Trends in modal shift away from cars were covered in Chapter 1. Looking specifically at new mobility services on willingness to forego personal car ownership, we found they do have an impact. Our regression analysis of the survey results showed that regular usage of multiple new mobility modes positively impacts readiness to give up car ownership. For example, if a person uses four different new mobility modes on a regular basis (i.e., more than two or three times a month), he or she is more likely to give up a personal car than a person using only two new mobility services.

- On an individual mode level, we found that car-sharing and ride-sharing services, as well as the use of MaaS solutions, are more likely to impact readiness to forego car ownership than other services, such as two-wheeler sharing and ride hailing; a statistically significant association between usage of the mode and readiness to abandon a private vehicle is confirmed only for the first three modes and isn't confirmed for the last two.
- This is likely due to the fact that car sharing and ride sharing both cater to the typical use cases of car users, such as doing errands, picking up goods and/or people, and traveling to and from city centers. These use cases are not well served by two-wheeler and ride-hailing services.

Turning to new mobility operators' pain points, these are to a large extent related to the challenges of moving from the "rapid growth" to "maturity" stages. In particular:

- **Raising funding is difficult.** Venture capital (VC) investment has been instrumental to the rapid launch, spread, and expansion of new mobility services, though the outcomes have been mixed. High expectations, regulatory hurdles, operational challenges, and the impact of the COVID-19 pandemic led to a drying up of VC funds, causing investors to shift their focus. Despite some disappointments, this period underscored the significant role private investment plays in advancing sustainable mobility. Expanding the sustainable mobility offering, particularly through shared mobility and DRT in wide suburban areas necessitates private investment. For investors to realize stable and substantial returns, they must exhibit reliability and a willingness to engage over the long haul. In parallel, it is imperative for local and regional authorities to develop strategies that attract these investors and provide the necessary oversight and assistance to ensure that investments are directed effectively (see Section 2.8).
- **Complexity and costs are growing.** In 2023, the number of permitted new mobility operators and vehicles was reduced in Berlin, Rome, Brussels, and many other markets, with Paris banning shared e-scooters altogether. At the same time, authorities are establishing rules and conditions that generate costs and constraints for mobility service providers. Issues such as parking restrictions, crime, vandalism, and difficulties with integration into broader MaaS solutions have added to the complexity and cost burden.

Consequently, only a handful of operators have showed signs of profitability so far, such as Lime and Ryde in 2022. Meanwhile, Bird's US branch filed for bankruptcy, Superpedestrian shut down its US operations and is exploring the sale of its EU branch, and Dott and TIER sold nextbike after their merger. Late last year, Micromobility.com delisted from the Nasdaq due to its low share price, and several players have laid off employees. Economic viability is therefore uncertain, and in the medium term, it may even be necessary to consider public subsidies in order to keep new mobility services as part of the menu.

18 "Future of Mobility Worldwide Survey (Q4 2023)." Arthur D. Little, forthcoming, 2024.

Recommendations

Our analysis confirms that usage of multiple new mobility services positively impacts readiness to give up the use of private car by default for all trips, and that micromobility, shared mobility, and on-demand mobility services have an important role to play in improving the modal split within our rmobility systems. They are especially valuable in encouraging modal shift and, with the possibility of increased service diversity, quality, and reliability, creating a virtuous circle. Transport authorities, PTOs, and new MSPs thus have a shared interest in bringing about the shift away from private cars. But there are some significant challenges to be overcome to ensure new mobility services can remain part of the equation.

Transport authorities should cultivate new mobility as part of their menu and foster partnerships with new MSPs to ensure a positive contribution to sustainable mobility, rather than merely seeking to regulate them:

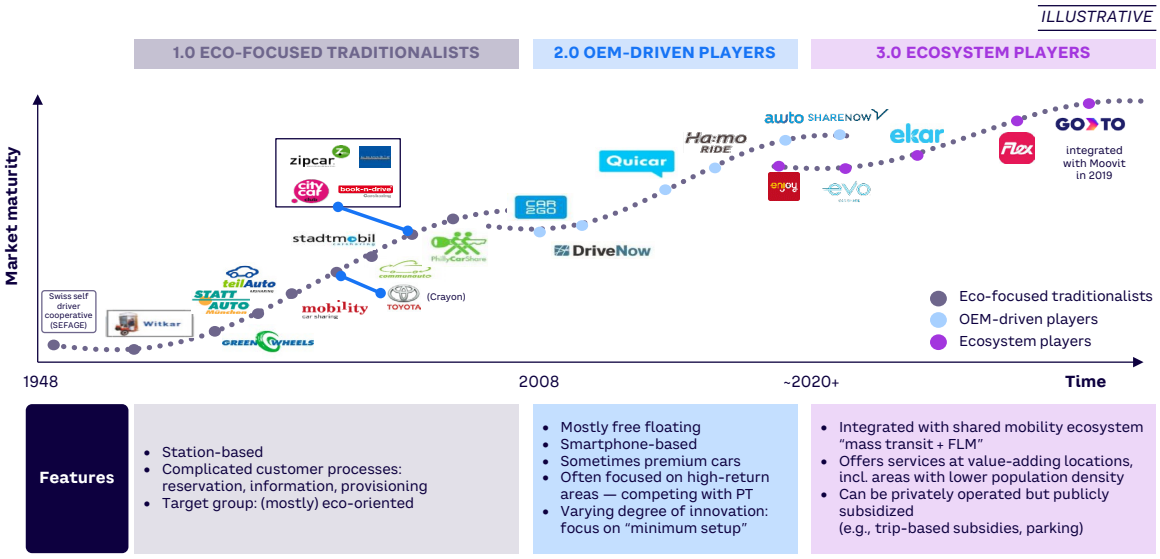
- **Adopting a balanced policy toward new mobility,** where supply management is complemented by demand management. In addition to improving supply of alternatives, a balanced mix of other measures, also on the demand side, is necessary to effect change. Further details on demand management, including nudging and communications policies, are provided in Section 2.7.
- **Carefully calibrating support structures for different mobility options.** More attention is needed to promote solutions with greater potential to shift citizens away from private cars, such as car sharing, in addition to continuing to promote bike lanes and bike sharing.
- **Taking a greater interest in "ecosystem plays"** to maximize success and help improve the economic viability of new mobility players.

Operators should position themselves as team players in the mobility ecosystem:

- **Integrating as much as possible with public transport and other transportation modes,** both physically (intermodal mobility hubs, interchanges) and digitally (MaaS).
- **Collaborating with transport authorities to codesign innovative support mechanisms such as micro-subsidies.** These can be positioned as benefits to both sides: the operators can secure better margins, while the authorities can benefit from being able to influence how and where new mobility services are provided (e.g., low-density areas, disadvantaged user groups, and off-peak times).

Figure 15 is an illustration of the application of the ecosystem play concept to car-sharing service providers, as detailed in the ADL Report published earlier this year in collaboration with movmi, a shared mobility tech company, and the Mobility Cooperative.[19]

Figure 15. The "ecosystem play" concept applied to car-sharing service providers



Source: Arthur D. Little

19 Van Audenhove, François-Joseph, et al. "Sharing in Success — How Car Sharing Can Deliver on Its Potential in an Ecosystem Play." Arthur D. Little/movmi/Mobility Cooperative, February 2024.

2.5 MOBILITY AS A SERVICE

Context

The MaaS concept gives consumers the ability to plan, book, pay for, and use multiple types of mobility services through one or more digital channels, as an alternative to personal ownership of mobility devices. The promise of MaaS is to benefit all stakeholders:

- Consumers have an improved experience through the ability to move through multiple mobility options based on preferences and circumstances while avoiding the costs of ownership.
- Cities and authorities can use MaaS to orient behavior toward more sustainable mobility patterns such as public transport, active mobility, and shared mobility while increasing accessibility and inclusiveness and optimizing flows and assets at the system level.
- MSPs have an additional channel to engage with users, giving them better access to understand customer needs, which in turn leads to reduced customer acquisition and support costs and opens up the possibility of real-time optimization of each of the mobility offerings.

If implemented the right way, MaaS has great potential to enhance the attractiveness of sustainable mobility options as an alternative to individual car ownership by default.

In 2021, ADL examined the current state of MaaS and identified key success factors critical for surmounting existing challenges and ensuring its successful development.[20] What developments have occurred since then? MaaS implementations to date have been limited to one-size-fits-all travel planners, not focused on specific use cases, with a limited number of fully integrated MSPs for ticketing and payment, while others are only partly integrated. However, we are seeing some interesting trends, including a general move away from business-to-customer (B2C) models that are financed with private capital, toward government-to-customer (G2C) models led by PTAs or operators. The difficulties of the MaaS B2C model are well illustrated by the fate of Finnish firm MaaS Global, one of its most prominent exponents, which after several attempts at pivoting its business model filed for bankruptcy in March 2024.

Although most G2C schemes are still "walled gardens" in terms of data sharing, there are signs of a shift toward more openess in the public MaaS platform, either through making public MaaS platforms accessible to a third party, as pioneered in Vienna (Upstream) and contemplated in Brussels, or through deployment of a public-led multicity MaaS patform, as in the Solent Region in the UK (Breeze) as part of the Department for Transport's Future Transport Zone program.

Business-to-business-to-employee (B2B2E) models have also seen some positive evolution over the past two years, triggered by fiscal incentives, especially in Western and Central Europe. Several vendors and B2C players are moving to this model. We are also seeing a rise in MaaS B2C models targeting specific use cases with better returns, such as tourist MaaS (e.g., Alpine Pearls) and rail/aviation MaaS (e.g., doco by Renfe in Spain and AirAsia MOVE). Another B2C variant involves mobility services offered as an integrated feature of another set of services, such as insurance, rent (business to tenant), banking (sometimes called "mobility as a feature"), or within super-apps. There are also some promising rural MaaS applications that focus on accessibility, in which the business case is more about cost savings for regional authorities than new revenue streams.

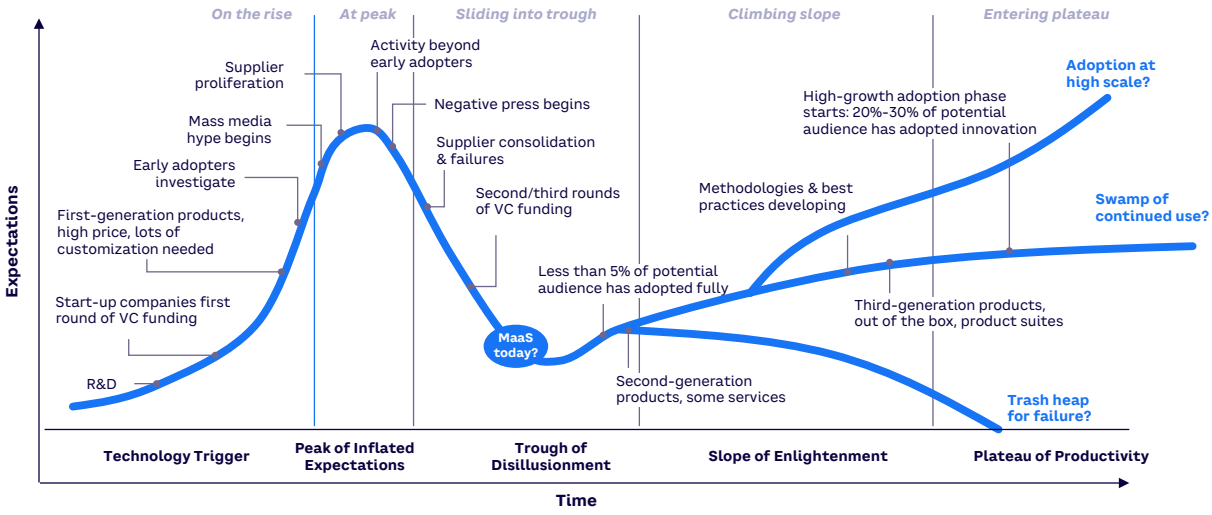
Moreover, there have been positive efforts to evolve regulations, standards, and codes of practice to accelerate MaaS deployment and ease relationship management across various stakeholders, including multimodal travel information services (MMTIS) and multimodal digital mobility services (MDMS) in Europe.

Challenges

Despite pockets of progress and the positive trends in certain types of MaaS business models, MaaS expansion has been slow overall, and MaaS-powered trips still represent a tiny proportion of all mobility trips worldwide. We must conclude that up to now, MaaS has not delivered on its promise. In terms of the Gartner hype curve, with less than 5% of the potential audience for MaaS adopting it, we are probably close to the "Trough of Disillusionment" (see Figure 16). Whether, and how, we can climb the "Slope of Enlightenment" is the key question that needs to be addressed.

20 Van Audenhove, François-Joseph, et al. "How to Realize the Promise of Mobility-as-a-Service." Arthur D. Little, September 2021.

Figure 16. Where is MaaS on Gartner hype curve?



Source: Arthur D. Little

We need, however, to recognize that a period in the trough is not unusual for developing technologies; indeed, AI is a good example of a new technology that spent many years in the trough before the massive acceleration we see today.

Analysis, insights & conclusions

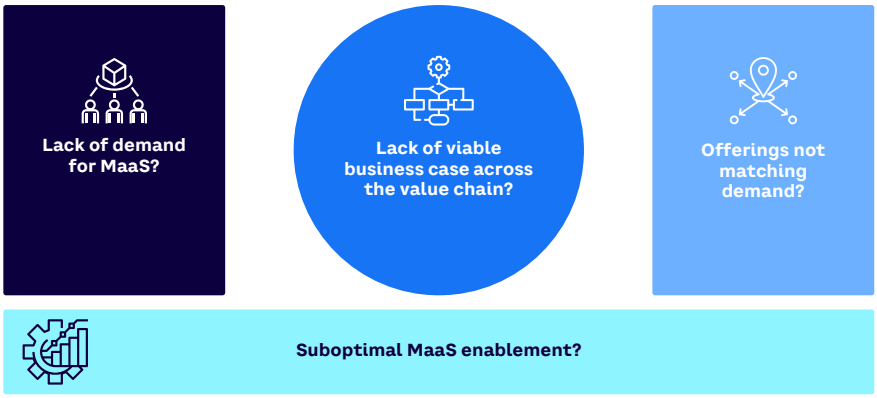
Our knowledge and understanding of the impact of MaaS is still relatively limited. At the microlevel, there have been some studies on user behaviors and attitudes toward MaaS, but most have been "stated preference" studies or small tests. At the meso level (i.e., the ecosystem level), many studies have focused on cooperation, driving forces, and barriers but fewer on business models and economic sustainability. At the macro level, there have been a few studies of the broader effects of MaaS on society and the environment, but most have relied on modeling with limited research evidence. In fact, there is a lack of large-scale implementations to date, and in any case, most of these are limited to Level 2 (which means integration of finding, booking, and payment). Many pilots are not properly evaluated due to insufficient data sharing. We do not yet know all the answers.

However, we do know from pilot studies that access to MaaS does influence modal choice, but mostly for "mode-agnostic" travelers; hence, car ownership is not being replaced. On the other hand, we also have seen that subscription-based models can lead to more significant behavioral changes. Using MaaS as a complement to sales channels, such as parking apps, can help increase public transport ridership. We know that MaaS works well, and with more viable business cases, when answering to specific use cases, including tourism and business-to-enterprise-to-consumer (B2E2C) models.

We also know that international one-size-fits-all B2C services are not likely to be successful — there will be no "Netflix of mobility." Simply putting mobility services under an umbrella app is not enough to create value for users, MSPs, or public authorities in terms of sustainable mobility gains. Recruiting MSPs into a mobility system without first proving increased reach or revenue tends not to work, as use cases are often misaligned. And whether synergies between MaaS and other services will ever deliver sufficient value is still an open question. MaaS is still not commercially attractive enough in many settings.

In the absence of reliable study data, we have tried to analyze possible root causes for MaaS falling short of its promise, using our experience as strategy consultants advising cities and operators and as entrepreneurs driving MaaS deployments. Overall, we see four types of root causes for the lack of MaaS progress (see Figure 17): lack of demand, offerings not matching the demand, suboptimal MaaS enablement, and lack of a viable business case. Below, we explore each of these.

Figure 17. Root causes of barriers to MaaS progress



Source: Arthur D. Little, RISE

Lack of demand

Demand for good public transport is high but does not cover all the needs of all users, such as door to door. Another example with high demand — and willingness to pay — is micromobility, especially e-scooters, e-bikes, and bikes. MaaS helps enable intermodal trips, which is a single journey that combines public transport with other modes as part of the same journey. A typical intermodal combination would be a metro or bus followed by a micromobility rental (bike or e-scooter) for the last part of the journey. While the percentage of intermodal trips in cities (i.e., using multiple modes for one journey) is typically less than 5%,[21] there seems to be more demand for multimodal life (i.e., using different modes for different journeys on different occasions, both within and outside cities). This provides a clear case for integrating *all* types of mobility services, including car-related solutions, such as car sharing, ride hailing, traditional taxis, and even private cars, which MaaS can facilitate.

However, many local people feel they are already aware of the best mobility options available for routine daily needs and do not need the additional support a MaaS channel offers. Once they have the information they need on their journey and have selected their preferred option, they do not mind using multiple applications. Therefore, in order to target daily users (which is essential since they represent a large proportion of all trips), MaaS needs to offer more advanced features beyond plan/book/pay (see also "Recommendations" later in this chapter).

MaaS SOLUTIONS MUST PROVIDE ADDITIONAL VALUE OVER AND ABOVE THE SUM OF THEIR PARTS

Another important conclusion is that tourists constitute one of the most important markets for the end-to-end plan/book/pay functionalities that MaaS offers because tourists need simplicity, are not familiar with the local ecosystem, and do not want to search for and install multiple local apps.

Offerings not matching the demand

A common failing is insufficient investment in the necessary physical solutions and infrastructures to provide the required service and customer experience, in addition to the digital components of MaaS. The situation has worsened post-COVID, as in many cities and regions, passenger and trip numbers have either recovered or increased while investment has declined. Labor shortages have also affected the availability of PT staff, especially drivers. A second issue is that the accessibility, reliability, relevance, and pricing of the included mobility services are often not attractive enough. Third, the attractiveness of a MaaS offer is often limited by its functionalities. As many MSPs have their own increasingly sophisticated front-end apps and journey planners are becoming more effective, for MaaS solutions to be considered attractive, they need to provide additional value over and above the sum of their parts.

21 Five percent refers to intermodal trips (i.e., combining more than one mode in one journey) and is excluding walking, which is often the first leg of many trips.

Finally, MaaS offerings are not always aligned closely enough with the specific use cases of customers. One example of good customer use case alignment is the B2B2E approach as mentioned above which, coupled with fiscal incentives, has led to the highest increase in demand for MaaS offerings over the past two years. This is also a good example of how public and private collaboration can move the needle.

Suboptimal MaaS enablement

The lack of collaboration between traditional PTOs, MaaS providers, and third-party MSPs presents a major barrier to the acceleration of MaaS deployment. Few PTOs have opened their systems for third-party ticket reselling, and even fewer allow reselling of monthly passes or flexible tickets/subscriptions. Current regulations to support such collaboration are still insufficient. The sidebar "The importance of providing open access to MaaS operators" offers some more detail on open data sharing.

Lack of a viable business case

Apart from specific use cases, the business case for MaaS operators is challenging due to low margins and difficulties in building sufficient volume. The lack of volume and high competitive intensity are also making it challenging for MaaS vendors, limiting their ability to invest. Apart from micromobility players, most MSPs don't see the value in being integrated into MaaS services and having to give up precious margins, while the current MaaS scope does not necessarily cover their customers' needs. Money can be found in the economy of car ownership, which is something that MaaS still needs to tap into. Subscription-based services can create more value for all parties, but it is a hard sell.

The importance of providing open access to MaaS operators

Public transport operators and transport authorities are often hesitant to provide open access to MaaS operators. This reluctance is due to the fact that public transport is a public service obligation funded with public money as well as by the lack of clarity within existing regulations.

Public transport should be the backbone of MaaS in order for MaaS to be sustainable and price competitive compared to car use and ownership. MaaS operators must have access to information related to mobility options and be able to resell tickets, including monthly passes, to attract potential multimodal users. It is important to distinguish between (1) the need for PTOs and commercial service providers to share information (including timetables, prices, and real-time data) and (2) the need for MSPs to provide open access to ticketing. Sharing information is in the best interest of all actors and should be done without any conditions. However, PTOs and transport authorities should not grant access to resellers under just any condition or price model. Instead, they should set clear terms and conditions when providing open access to ticketing to MaaS operators. These terms/conditions include: proving that new customers/more PT traffic are being added, ensuring that existing customers are not being cannibalized, making sure that data is shared at a granular level to avoid losing insights into customers, and proving that the subsidy is not being exploited by "over-creative" price models if they are allowed to work with subscriptions. Finally, PT authorities should work with MaaS operators as partners who add value to the mobility system; if the initial cooperation models don't work or a reseller breaks the rules or trust, they should have the power to end or modify the terms and conditions.

Recommendations

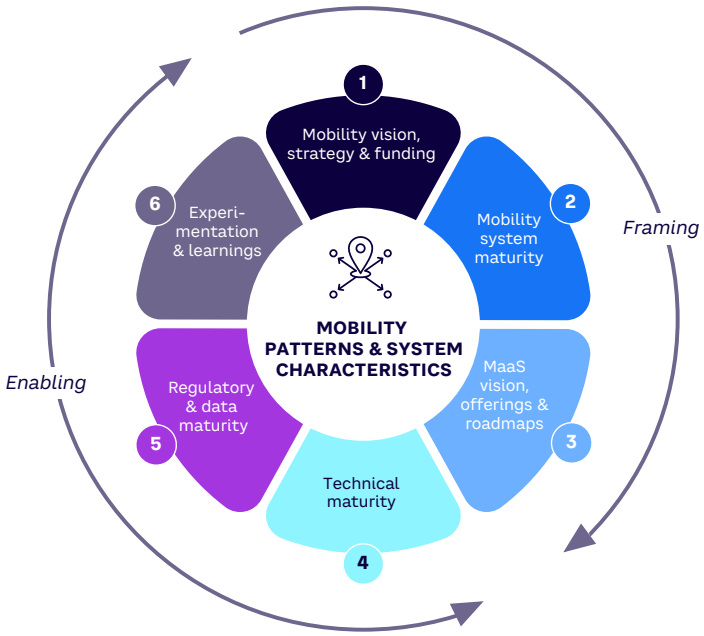
Despite current setbacks, we believe that MaaS is here to stay. Given the mobility challenges ahead and the evolution of mobility patterns and usages, there are huge benefits ahead that justify continuous efforts. Overall, MaaS has the potential to revolutionize the way we move around cities, but moving ahead requires a more comprehensive approach and more effective collaboration between public and private stakeholders to make it a reality and unlock the potential of MaaS at the system level. We offer the following recommendations to help progress and accelerate MaaS deployment.

Transport authorities within cities and regions should pursue a key role in setting priorities to fully extract the value of MaaS at the system level. This includes:

- Adopting a comprehensive approach to frame and enable a virtuous sustainable mobility system powered by MaaS
- Taking ownership of the overall roadmap and playing a coordination role, encouraging public/private collaboration in an open ecosystem logic
- Actively participating in the financing (and ownership) of certain elements of the roadmap; for example:
  - Overarching integration layers between different routing, ticketing, and payment engines
  - System-level data management functionalities
  - Dynamic regulation enforcement functionalities toward MSPs
  - Multimodal route planners, ensuring all routes (including cycling routes) and options are presented in a way that nudges sustainable choices
- Financing/delivering marketing campaigns to promote sustainable mobility, including public transport, active mobility (walking and cycling) and new mobility, and nudging behavior changes

The MaaS 360-degree framework (see Figure 18) identifies six dimensions to address, which together can drive progress and provide a valuable way to assess the maturity and effectiveness of a MaaS-powered mobility ecosystem. These dimensions fall into two broad categories: (1) **framing** (i.e., setting the right frameworks to allow for a virtuous MaaS system) and (2) **enabling** (i.e., concrete actions to encourage cooperative and effective MaaS development). Transport authorities should take action in both categories.

Figure 18. ADL MaaS 360° review framework



Source: Arthur D. Little

Framing dimensions

- Establish a clear overall mobility vision, policy, strategy, and funding that consider mobility patterns and system characteristics, and define a suitable ecosystem governance approach.
- Develop the mobility system to the required maturity level by investing in physical solutions and infrastructure, and match the mobility needs of citizens and enterprises, including considerations related to spatial coverage, quality, frequency/volume of units, accessibility, and price.
- Promote and progressively develop a MaaS vision, offering, and roadmap that caters to relevant customer use cases and makes sustainable mobility options more visible and journeys more seamless.

Enabling dimensions

- Implement the right technology building blocks to encourage MaaS; for example, a suitable platform design, the ability to integrate MSPs into the system, and an effective administrative system.
- Establish the necessary regulatory frameworks for MaaS; for example, policies to trigger open collaboration across actors (e.g., share information with all actors, provide open access to ticketing by PTOs as well as MSPs) and demand management policies to incentivize more sustainable behaviors by both actors and users.
- Enable testing and experimentation, with a specific focus on ensuring learnings are extracted and shared to foster continuous improvements.

MaaS operators, whether public or private, should adapt their offerings to provide value propositions that deliver on the real promise of MaaS, rather than simply digitizing mobility distribution:

- Review MaaS offerings to ensure they are catering to specific use cases (i.e., providing answers to specific pain points of target use segments rather than one-size-fits-all offerings).
- Apply one or more of the three routes outlined in the sidebar "Making MaaS greater than the sum of its parts": (1) provision "over the top" functionalities (front-end, client-facing or back-end, system-enabling); (2) improve attractiveness to specific audiences (e.g., tourists, commuters, tenants) and/or reach new audiences (e.g., car users); and (3) contribute to realizing sustainable mobility policy objectives.
- Ensure that MaaS interfaces are well designed to nudge and influence mobility behaviors. Present routing options to suggest preferred sustainable modes while respecting freedom of choice; for example, setting sustainable modes as the default option or providing discounts or positive reinforcement in case such modes are chosen (see sidebar "Nudging & marketing to influence mobility behaviors" in Section 2.7).

PTOs and commercial MSPs must open up, share information and services, and work together for the greater good in an evolving open mobility ecosystem:

- PTOs should collaborate with other MSPs in an "open ecosystem" logic for the greater good of sustainable urban mobility.
- PTOs and MSPs should share information (timetables, prices, and real-time data) and provide open access to ticketing and payment under proper conditions (e.g., single tickets as well as monthly passes or flexible tickets/ subscriptions).
- PTOs should collaborate with local and regional authorities to accelerate the development of physical intermodal mobility hubs, building first on existing PT hubs.

Finally, suppliers and investors should invest in services and solutions that will contribute to the development of virtuous MaaS ecosystems.

Making MaaS greater than the sum of its parts

In the context of increasingly available and efficient journey planners (potentially powered in the future by AI) and with most MSPs developing their own front-end apps to simplify distribution, ticketing, and payment, as well as offering additional features to enhance customer experience and loyalty, MaaS cannot meet market demand in the long run by simply integrating all the functionalities of the underlying modes' apps. We have identified three routes for MaaS to provide greater value to users and/or citizens and the system at large:

- **Route 1: Provision "over the top" functionalities not covered by underlying apps.** These functionalities should be at the system level, building on the fact that MaaS integrates all or a majority of mobility options. They can be of two types: (1) client-facing functionalities located in the front-end apps, providing additional features to end users and taking advantage MaaS positioned at the system level; for example, functions supporting or nudging intermodality trips and multimodal life; or (2) system-enabling functionalities located in the back end, providing increased effectiveness (improved overall services) or efficiency (economies of scale) at the system level.
- **Route 2: Improve attractiveness to a specific audience (e.g., tourists, tenants, commuters) and/or reaching new audiences (e.g., car users).** Tourist and tenant audiences both have specific needs that can be built into MaaS. Car user features could include car parking, integrating with private car park operators and P+R facilities, navigation services, or information on car-relevant demand management measures, such as congestion charging.
- **Route 3: Contribute to higher, system-level mobility policy objectives by influencing mobility behaviors through the development of so-called MaaS Level 4.**[1] MaaS should not be limited to the digitalization of the distribution of mobility services. When properly framed, it can also be a powerful tool in the authority's toolbox to enable sustainable mobility and contribute to achieving broader policy objectives, ultimately leading to a better quality of life for citizens. This is sometimes referred to as "MaaS Level 4" and can be achieved by multiple means, such as increasing the attractiveness of shared mobility systems, offering information and incentives toward more sustainable use of mobility (as recently piloted in Rome), offering smart subscriptions, optimizing mobility flows and assets, collecting and processing mobility data, and promoting intermodality and multimodal life.

1 Sochor, Jana, et al. "A Topological Approach to Mobility as a Service: A Proposed Tool for Understanding Requirements and Effects, and for Aiding the Integration of Societal Goals." *Research in Transportation Business & Management*, Vol. 27, June 2018.

2.6 AUTONOMOUS MOBILITY

Context

For many years, autonomous driving (AD) has been discussed as a key part of the mobility systems of the future.[22] As recently as a few years ago, expectations were high that fully autonomous or partially automated vehicles would imminently be able to address several critical issues in mobility systems, such as:

- An increasing shortage of PT bus drivers and high employee costs as a proportion of total operating costs
- Safety incidents in dense urban traffic where vehicles share space with cyclists, e-scooter users, and pedestrians
- Helping solve the "last mile" problem through PT feeder systems with self-driving shuttles and taxis, so as to better serve peri-urban and rural areas
- Increasing the attractiveness and service level of PT to help drive modal shift away from private vehicle use in urban environments
- Better mobility efficiency and sustainability, which AD can deliver through more consistent, regulated, and adapted driving due to automated features, leading to lower energy consumption, especially with connected systems

As urban agglomerations grow and become more densely populated, the mobility needs in those cities increase. Traffic planners and authorities are increasingly contemplating AD as one piece of the overall traffic system puzzle. In the US and Middle East, the focus has been on the development of robotaxis to replace ride hailing and private cars, with IT giants and OEMs in the lead. In Europe, considering the focus of transport authorities on improving PT systems and active mobility, replacing private conventional cars with private, self-driving cars is generally not the objective, and robotaxis (ride hailing) are often, if not always, deprioritized in favor of the development of mass transit automated PT modes that could help improve accessibility and reduce congestion.

Urban dwellers expect affordable, convenient, and always-available services in order to consider them as relevant alternatives to a privately owned car. Automated services must be well connected to other public modes of transport and easily accessible. These objectives of more inclusive, safe, efficient, and sustainable mobility were promoted by the European CCAM (Connected, Cooperative, and Automated Mobility) Partnership.

However, AD technology, while developing steadily, has progressed much more slowly than was predicted during the "hype" years of the last decade. While automated trains, metros, and trams in places like Dubai, Vancouver, Singapore, Nuremberg, and many other cities have been operating successfully for many years, even with significant progress in technology over the past year, road-bound AVs are still awaiting a true breakthrough.

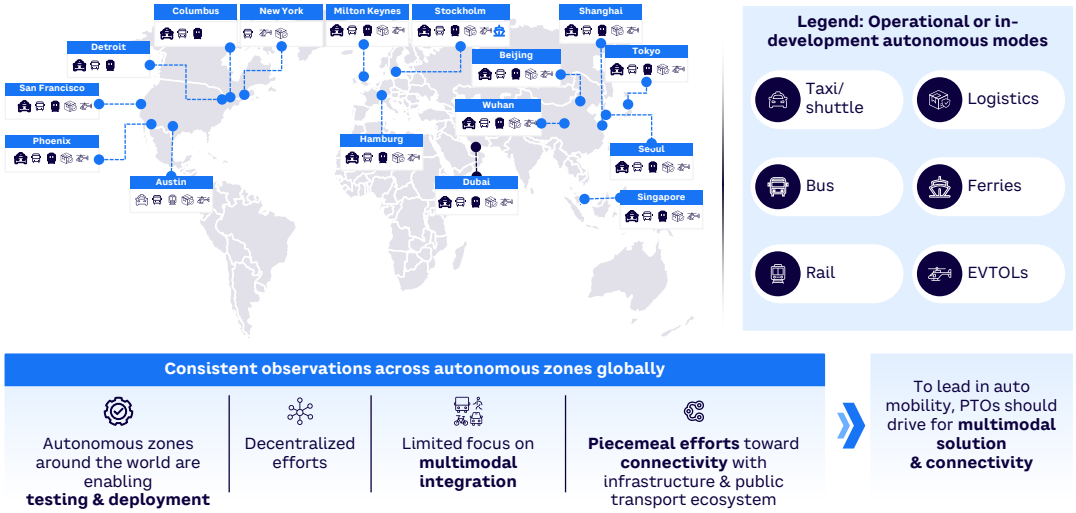
For buses, AD is still limited to small vehicles (mostly carrying fewer than 10 passengers) at low speeds and in controlled environments like campuses or other controlled sites rather than in dense, mixed traffic. Beyond this, there are many pilot projects. For example, Oslo's transport authority Ruter is conducting a promising three-year pilot in the 22-square-km Grorud Valley suburban area, offering a fully autonomous shared on-demand service without a safety driver to complement the existing high-capacity PT system.

In the US, pilot projects are focusing on robotaxis (e.g., in San Francisco, Houston, and Las Vegas). Dubai has also tested autonomous buses of different sizes in a sandbox approach, with deployment expected soon. China seems to be most advanced in autonomous with L4[23] bus deployments, led by Guangzhou-based WeRide.

We have mapped deployments globally by looking at the current status of AV technology (see Figure 19).

22 Here, autonomous (or "autonomy") refers to full automation; that is, the automated driving features do not require that you take over driving and thus do not require a steering wheel (SAE Level 4 and 5). Automated (or "automation") is everything on the way from Level 0 to Level 5.
23 L4 refers to AVs that are fully self-operational within set boundaries, requiring no attention or assistance from a human driver.

Figure 19. Global autonomous vehicle developments



Source: Arthur D. Little

Challenges

The slower-than-anticipated progress in AD points to the numerous challenges it faces:

- First and foremost, **despite significant progress in the past year,** technology readiness for uncontrolled urban environment has still not been **fully** achieved, **even if it may be the case sooner than most may think.** Urban traffic is the most complex operational design domain (ODD) that AD needs to be able to cope with, involving many different vehicles, speeds, signs, buildings, road conditions, markings, and unpredictable situations with human interactions and unwritten rules. Computing capacity, speed, and latency are still not sufficient for this level of complexity or for high driving speeds. Human errors are, to an extent, accepted by most people, but errors by driving machines are not.
- **Public acceptance is still poor.** Although there are regional differences, such as between Asia and the US and Europe, generally people don't feel safe enough with AVs, as a recent global ADL consumer survey revealed. Potential AV driving errors are the most-mentioned concern (65% of respondents globally). While more than 60% of respondents in China demonstrate a positive attitude toward AVs in their country, this value is below 30% in Europe and slightly above 30% in the US.
- **The business case is still lacking for robotaxis — especially in the case of autonomous shuttles and buses.** Sensors are high-tech and expensive, without any economies of scale up to now. If human safety drivers are still needed, the key economic upside is lost. Passengers are not willing to pay extra for AD, and other potential positive external effects (e.g., benefits to the environment and/or the overall mobility system for certain use cases) are usually not reflected commercially.
- **There is still regulatory inconsistency and uncertainty.** While the EU implemented homogenous rules and standards for type approvals of AVs in 2022, regulations for AV testing and operation are still different on national levels and, in some cases, nonexistent. This is also the case for the US and its different states.
- In Europe, **the focus on mass transit automation seems to hinder local progress from a technology perspective** compared to other regions like the US and China, where primarily robotaxi companies collect vehicle miles, data, and experience (besides the absence of large digital tech companies).

Analysis, insights & conclusions

In our analysis, we sought to provide insight on the current AD status and what needs to be done to overcome challenges, focusing on technology, use cases, business models, and human acceptance. This analysis is based on insights from client strategy and benchmarking projects, working with local and regional authorities, and input from experts from POLIS and elsewhere. It is also based on the previously mentioned ADL "Future of Mobility" survey,[24] which included questions about acceptance of autonomous and shared mobility modes.

Looking back over the last decade, AV development has provided a good example of the "hype curve," as safety concerns following various setbacks and one fatality in 2018 led to a new perception of AV potential (see Figure 20).

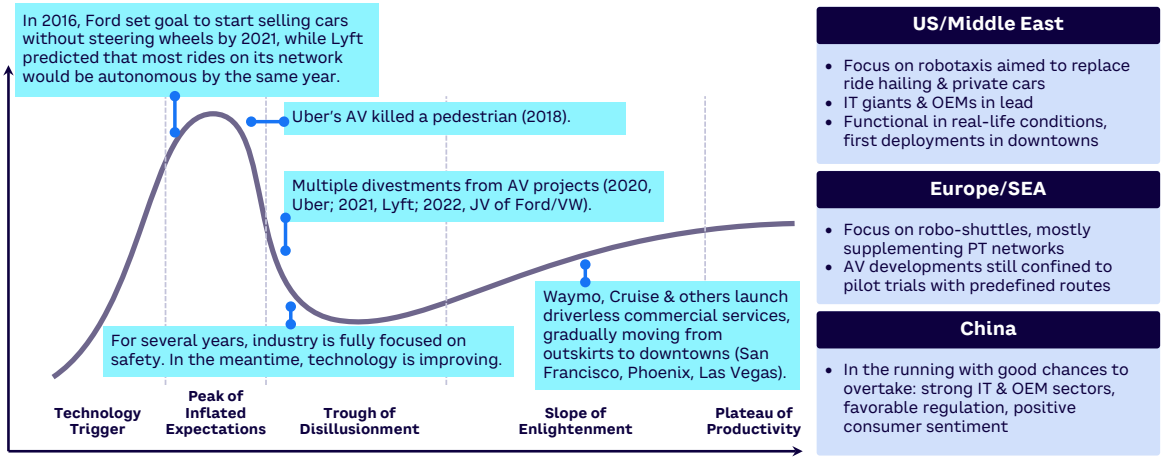
L4 technology has still not achieved the breakthrough level needed for general application in mixed traffic. Current L4 testing and deployment is mainly based on the creation of autonomous zones, which are controlled environments with specifically prepared infrastructure, connectivity, signaling, and potentially the combination of various levels of autonomy and automation and various modes of transport. Buses have started operations or are being tested in several geographies, with multiple players aiming for certification and homologation. These bus operations are currently at low speeds in Europe. China is more advanced in terms of individual projects.

For example, the Guangzhou Huangpu District autonomous zone boasts the world's first on-demand platform for multiple AV modes and has been a major AV test bed. WeRide in Guangzhou and Baidu in Beijing and Shanghai operate established robotaxi and robobus operations. In the US, there have been L4 robotaxi operations without safety drivers in San Francisco, California, and Phoenix, Arizona.

Currently, buses or taxis in use can only operate in small, dedicated areas, as they require detailed and updated maps. Even cutting roadside greening can cause problems with map accuracy and vehicle orientation. Our benchmarking showed current gaps in capabilities for mixed urban traffic: most buses required extensive mapping and learning of routes and environments, and all had safety drivers and engineers aboard during testing. The maximum speed was around 50 km/h for some but not all operations. Buses required human intervention in many cases and in some cases did not react properly to traffic signs or even traffic lights.

That said, tech companies are optimistic about achieving full technology readiness for L4 commercial operations in mixed traffic for taxis and buses well before 2030. L5 operations (fully autonomous in every environment) are still far away, which means that for the foreseeable future, use cases and environments must still be selected and infrastructure prepared. This requires significant effort and investment.

Figure 20. Autonomous vehicle technology curve and differentiated geographical developments



Source: Arthur D. Little

24 "Future of Mobility Worldwide Survey (Q4 2023)." Arthur D. Little, forthcoming, 2024.

In the meantime, L2 automation (assistance from two automated features; for example, acceleration, braking, or steering) and L3 automation (requiring a human driver to actively monitor and take control) are available today and can also benefit PT applications. For example, while the need for a human driver eliminates the cost saving, economic gains can still be achieved from speed assistants and platooning,[25] including reduced energy consumption and less wear and tear, depending on the use case. At a more basic level, L1 automation (at least one automated feature, such as blind spot assist) already provides safety benefits. This will be required in the EU for buses from mid-2024 onward.

With further developments in technology and building on previous pilots and trials, we expect regionally different scenarios for the upcoming years. In Europe, the focus will likely continue to be on a more progressive deployment of AVs in PT to accelerate the transition to autonomous transport systems and overcome bottlenecks in workforce and coverage. Meanwhile, the US and China will likely continue a mixed approach of buses, shuttles, and robotaxi services, with a focus on the latter (especially in the US). Those robotaxi services could improve in service quality over the years and after 2030 finally evolve from offerings in limited areas to full city coverage or beyond.

One way to accelerate earlier beneficial AD implementation is to rethink use cases and reduce expectations (see Figure 21). These considerations should also include regional requirements, cost structures, infrastructure, and regulatory conditions.

In Europe, bus depot automation is a promising use case based on current technology, providing benefits in terms of freeing up costly driver time, reduced parking space, controlled safety, and scalability across multiple depots. Urban/campus shuttles provide a useful on-demand service, point to point or fixed line, but are mostly supplemental rather than replacing an existing PT service. To improve coverage, rural and peri-urban on-demand feeder services can help connect to PT hubs on a 24/7 basis and are more technically feasible due to lower traffic density and complexity. BRT services require a dedicated lane anyway, so automation is much easier. This solution is easier to implement in road infrastructures in North America, the Middle East, and China, compared to dense historic European cities. The most complex use case is an automated urban fixed-line bus service. Although not part of the scope of this study, logistics use cases are also promising, due to lower safety and comfort requirements and easier loading/unloading patterns.

The lack of a viable financial business case is, after safety, the second most crucial current barrier to AD implementation. The key business benefit of autonomy is the workforce crisis in PT; there is a lack of drivers and the costs to employ them are going up, especially given the expectation for PTOs to improve and extend their offerings in tight economic environments. Driver costs are the largest share of PT operating expenditure — usually around 60% in Europe and the US, as mentioned in expert interviews and confirmed by data from the US Department of Transportation. L4 automation reduces these staff costs and limits the need to deploy large vehicles generally, allowing for more flexibility. However, these benefits will not be achievable until L4 application in mixed traffic is possible.

Figure 21. Autonomous vehicle development use case overview for public transport

Source: Arthur D. Little

25 "Platooning" refers to driving sets of vehicles together.

Currently, technology and sensor costs remain high in comparison to the costs of a minimum wage driver in a simple car, which makes business cases for robotaxis less attractive than larger vehicles. Robotaxis in the US and China only live from investor money from large tech companies with deep pockets, while AD bus projects in Europe are paid for with public/taxpayer money.

Business case calculations are highly dependent on the region, use case, type of deployed vehicles, and scope of the system. Despite this variability, our analysis suggests that today there is no positive business case for AD in PT at a micro level, based on like-for-like replacement. However, at a mobility system level, there is more potential. For example, when automated buses replace more expensive train connections, the economic benefits can be greater. When other economic externalities are also considered, such as reduced congestion, emissions, and better use of space, the business case is actually even more attractive.

Turning to the challenge of human acceptance, our surveys confirmed that safety is the primary concern across all regions and incomes. This is followed by liability (i.e., who bears responsibility in the case of accidents), data security and privacy, and finally unwillingness to pay a premium. Further experience from pilot projects also highlights the importance of actual and perceived security of passengers in public vehicles without human drivers, especially in non-peak hours and areas of low utilization. The only way to address these concerns is to implement AD PT services based on a deep understanding of customer and system needs. This requires approaches like user surveys, travel-pattern analysis, simulations of impacts on people's movements, traffic, road use, energy use, co-creation with users, and user education. Starting implementation in situations where there is an evident gap or need for better mobility services also helps. Agility is needed in implementation, starting small, scaling rapidly and flexibly, and leveraging the right partner ecosystems. Inclusivity and accessibility are also key, and digital savviness cannot be a prerequisite. Customer confidence can also be strengthened through the availability of data displays and virtual travel assistants. In some cases, the presence of a human on board may be needed.

Recommendations

Overall, we can conclude that AD ultimately has the potential to play a significant role in solving mobility system issues. However, it should not be implemented for the technology's sake — people must want it, like it, and feel safe with it to make it a success; hence, inclusivity and accessibility are key requirements. Adopting a system-level approach is important, with regulations that are consistent but do not impose excessive cost. AD is not about individual automated or fully autonomous vehicles, but rather connected vehicles in smart traffic systems. The right use cases and applications must be selected for the most positive impact at the given technology readiness level rather than only aiming for the moonshot of AVs in mixed traffic.

We offer the following recommendations:

- **Considering regional strategies:**
  - **Europe.** Open up for modes beyond mass transit, such as robotaxis, as well as shuttles and buses. Enable and attract private investment through consistent and favorable regulation and creating real-life test beds at a larger scale.
  - **The US and Middle East.** Open up public transport modes by automating shuttles and buses along with robotaxis. Add public funding to improve the attractiveness of autonomous PT modes.
  - **China.** Leverage first trials of integrated autonomous modes to cover more regions, including creating consortia under public leadership. Create blueprints for implementation in other regions.
- **Local and regional authorities should ensure a system-level approach and holistic perspective:**
  - Ensure a system-level approach and holistic perspective in planning and setup of autonomous transport by implementing respective regulatory frameworks and requirements. Balance and connect/integrate public transport with individual transport modes (robotaxis).
  - Implement autonomous mobility and automation strategically in tenders, referencing the most suitable use cases.

- **PTOs should be more pragmatic and customer needs-driven:**
  - Identify issues and gaps in offerings and define use cases for AD with a more pragmatic perspective.
  - Actively develop offerings regarding AV and AD around key customer needs and technology readiness levels and ensure integrated offerings.
  - Include external (private) investors if required.
- **AV suppliers, developers, and manufacturers should focus more on AV technology integration with the mobility system:**
  - Prepare technology for integrated mobility systems and CCAM rather than solely for individual vehicle solutions.
  - Integrate infrastructure perspectives and solutions; create consortia and alliances.
  - Seek external, private funding.
- **Investors should balance investments to encourage public-private collaboration:**
  - Strengthen public-private co-investments to avoid a bias toward specific transport modes and to overcome one-sided financial burdens and risks to either taxpayers or private corporations (see sidebar "Reinventing public-private collaboration").
  - Balance investments between automation of public transport and automation of individual transportation, which requires co-creation of business cases at system level.

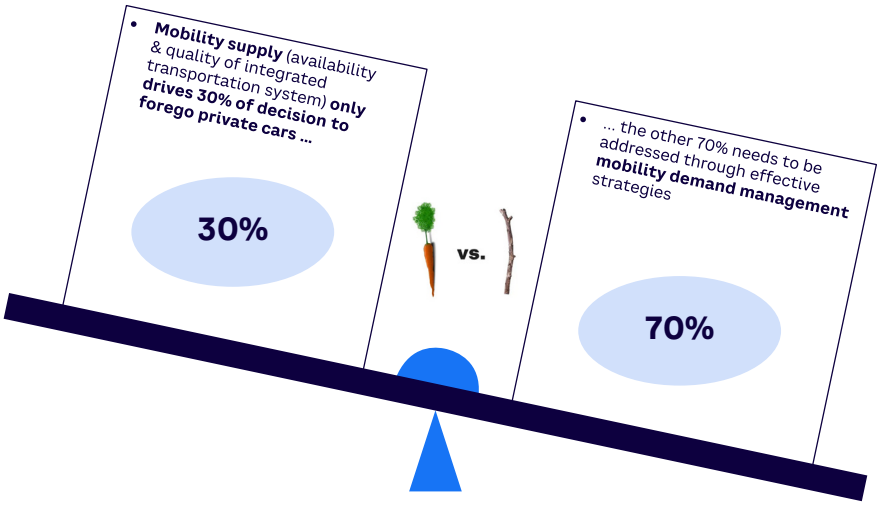
2.7 MOBILITY DEMAND MANAGEMENT

Context

In previous sections, we explored various solutions for improving the supply side of our mobility system. The latest "Future of Mobility" global survey showed, however, that the availability of alternative mobility services would influence only about 30% of the potential readiness to abandon private cars. The other 70% needs to be addressed through effective mobility demand management (MDM) strategies (see Figure 22). Influencing mobility demand is thus crucial to trigger a shift toward sustainable mobility behaviors.

> **INFLUENCING MOBILITY DEMAND IS THE MOST IMPORTANT FACTOR TO TRIGGER A SHIFT TOWARD SUSTAINABLE MOBILITY BEHAVIORS**

Figure 22. Drivers' willingness to forego private cars



Source: Arthur D. Little

In this section, we focus on how to tackle the demand side through MDM measures. MDM is defined as "the application of strategies and policies to increase the efficiency of transportation systems, which reduce travel demand, or to redistribute this demand in space or in time." Ideally, well-thought-out MDM will deliver a range of socioeconomic and environmental benefits. From a social utility point of view, it has the potential to reduce travel time, drive modal shift, enhance safety, improve personal health, and increase public space. Environmentally, it should help reduce emissions, decrease noise pollution, and improve air quality. These benefits are usually publicly communicated.

Challenges

There are several challenges for authorities in applying MDM measures. First, numerous factors affect mobility demand, from the configuration and management of cities to citizens' diverse life patterns and behaviors, making it difficult to select the best policies.

Second, some MDM measures may have negative externalities (e.g., controlling freedom of movement or limiting overall accessibility through disenfranchising less affluent segments of society or geographical regions) as well as upsides (social utility, environmental or economic), some of which can be indirect and hard to predict and affect different stakeholders in different ways. As these measures tend to be "sticks" rather than "carrots," there may be resistance from some stakeholder groups that needs to be recognized, and the political costs can sometimes be high.

Finally, some MDM measures are much more costly than others (e.g., incorporating high infrastructure investment or operating costs compared to changes in administrative regulation). The choice of MDM measures will vary for each city, based on its specific features and context. This all means that a systematic, rigorous, and transparent approach is needed to determine each city's best basket of MDM measures.

Analysis, insights & conclusions

Levers can be distinguished between push and pull factors. Push levers are the measures that restrict and/or discourage private motorized transport. Often, they are legally enforced through regulation, with consequences for noncompliance. Pull levers, on the other hand, are offered for use if desired, with the ability to avoid them if not interested. They are implemented through nudging or incentivization, where positive effects can directly be felt by the end user.

The following approach has been applied effectively in many cities and regions and is designed to help overcome the highlighted challenges. The starting point is to consider the full range of levers. There are approximately 40 standard levers that have been applied worldwide, split across three categories:

1. **Regulatory guidelines.**[26] This includes measures that directly restrict or change mobility demand, such as limited traffic zones, speed limits, low-emission zones, low-traffic neighborhoods/zones, dynamic tolling systems (including congestion charging), parking pricing and restrictions, access-contingent parking models, smart fares, usage-based taxes and insurance, and fuel pricing.
2. **Land use and strategic planning.** This encompasses measures concerned with physical configuration and usage, such as infrastructure development guidelines, land-use models, transit hubs, street design (vertical and horizontal deflection), company relocation, and use of mobility impact analysis. Several of these measures will be applied in the context of the mix of measures considered for the deployment of city of proximity concepts (see Section 2.2), but any can be applied independently.
3. **Personalized travel planning.** This includes measures to change personal mobility behaviors like marketing campaigns, staggered and flexible working hours, navigation support applications (including journey planners and MaaS), gamification, smart parking management, financial incentives, and so on. Corporate policies (e.g., salary incentives, encouraging teleworking, carpooling, and mobility planning) are also relevant and may inspire behavioral changes.

26 These are referred to as "urban vehicle access regulation" (UVAR) in Europe.

Using input from a panel of industry experts, the impact of each of the standard MDM levers has been systematically assessed and ranked on a relative 1-5 scale in terms of costs (implementation and operating costs plus externalities) and benefits (environmental, economic, and social). Mapping the results onto a matrix provides a clear picture of the attractiveness of different levers (see Figure 23).

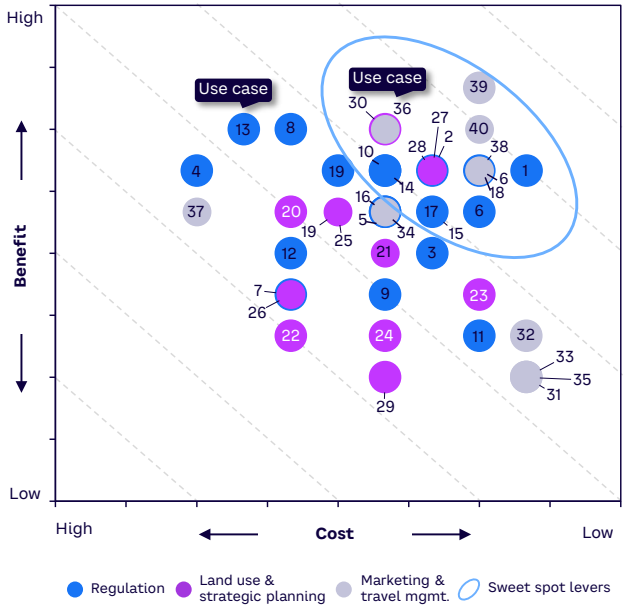
As Figure 23 shows, certain levers appear in a "sweet spot" with a very positive cost-to benefit ratio. In this case, the sweet spot levers are:

- **Regulatory guidelines** — peak hour speed limits, peak hour emergency lane usage, freight transport vehicles entry and movement restrictions, high occupancy vehicle (HOV) and express lanes, low-/zero-emission zones (including low-traffic neighborhoods), parking regulations and pricing, and dynamic tolling systems.
- **Land use and strategic planning** — infrastructure development guidelines and land-use models, site-based approaches (schools, commercial shopping areas, companies), and intermodal mobility hubs.
- **Personal travel management** — apps for sustainable mobility compensation (gamification, sustainable mobility nudging), tailored and digitally supported smart parking solutions (in the future combined with EV charging solutions), marketing and nudging campaigns, and navigation-support applications (such as journey planners and MaaS).

While the precise ranking will vary depending on the urban setting being considered, many of the top-ranking levers are common across most cities. There are some compelling use cases across the world that illustrate their effectiveness:

- **Congestion charging and dynamic tolling systems.** These have been successfully applied in Stockholm and Singapore to alleviate inner-city congestion. While Stockholm employs a cordon scheme covering a 35-square-km area, Singapore focuses on designated routes. Both systems have effectively alleviated congestion by 10%-20% since implementation and generated hundreds of millions in revenue while expanding the adoption of alternative modes (see sidebar "Future outlook — Dynamic tolling systems").

Figure 23. Ranking of MDM levers vs. costs and benefits



Regulatory guidelines
1 Peak hour emergency lane usage
2 High occupancy vehicle (HOV) & express lanes
3 Priority lanes
4 Reversible lanes
5 Dynamic (congestion) speed limits
6 Peak hour speed limits
7 Coordination of road detours/closures
8 Intelligent traffic signal mgmt
9 Dynamic or peak hour parking pricing
10 Limiting parking space availability
11 Parking pricing for commercial zones
12 Tolling system (static)
13 Dynamic tolling system (incl. congestion charging)
14 Increased vehicle registration fees
15 Vehicle use tax (fuel, carbon)
16 Vehicle tax
17 Low-emission zones (incl. low-traffic neighborhoods)
18 Freight transport vehicles entry & movement restrictions
19 (Limited) car-free zones

Land use & strategic planning
20 Park & ride facilities
21 Dynamic curbside management
22 On-street parking ban during peak hours
23 Bicycle parking
24 Intersection improvements
25 Improved bicycle lane network
26 Road network expansion
27 Infrastructure development guidelines & land-use models
28 Site-based approach (schools, commercial shopping areas, working districts)
29 Traffic mgmt. center
30 Intermodal mobility hubs

Personal travel management
31 Promote car-free days
32 Promote flexible employment & personal travel patterns
33 Promote remote work
34 Implement staggered working hours within public institutions (e.g., schools, city offices)
35 Promote remote learning
36 Marketing & nudging
37 ncentives for PT (mobility pass offers)
38 App for sustainable mobility comp. (gamification; sustainable mobility nudging)
39 Smart parking mgmt.
40 Navigation support applications (journey planner/MaaS)

Source: Arthur D. Little

- **Infrastructure development guidelines and land-use models.** Implementing strategic guidelines for sustainable urban mobility in Ljubljana improved city life and set the standard for long-term urban planning. Through limiting individualized passenger car traffic and expanding the PT offering in a holistic and integrated fashion, the city center has been reshaped into a more affluent, inhabitant- and tourist-friendly urban area, facilitating accessibility for all and significantly improving quality of life.
- **Marketing and nudging.** These influence behaviors toward the usage of more sustainable mobility modes, either through the introduction of gamification techniques within mobility apps (journey planner, MaaS, or super-apps) or through deployment of targeted marketing campaigns with convincing narratives around the benefits of more responsible mobility behaviors (see sidebar "Nudging & marketing to influence mobility behaviors").

Future outlook — Dynamic tolling systems

As urban areas face increasing congestion, city planners are exploring solutions that don't rely on expanding roads and parking infrastructure. Tolling systems are one solution. However, static parking fees and toll roads may not mitigate persistent congestion during peak hours as people prioritize convenience over cost.

Dynamic pricing adjusts tolls or fees to match the fluctuating demand on the infrastructure, overcoming this limitation. When demand is high, prices rise accordingly. Typically, prices are set based on time of day, with peak travel times incurring higher costs, but they can also dynamically change in real time based on demand. Comparable models of time-sensitive pricing exist in the energy and water sectors.

This approach encourages users to explore alternative transportation options. During peak periods, higher tolls and fees prompt a shift away from private vehicles, while lower costs during off-peak times are less of a disincentive. This eases congestion and enhances road capacity and travel-time reliability. Emergency services, freight, delivery, and tradespeople benefit from reduced congestion, enjoying shorter and more predictable travel times. As a tool for managing demand, dynamic pricing encourages shifts in travel behavior, promoting the use of public or active transport and prompting adjustments like telecommuting or off-peak travel.

It complements investments in public transport and infrastructure for walking and cycling. When integrated with real-time traffic management, it provides citizens with reliable and cost-effective travel options.

Modern dynamic pricing systems leverage technology to maintain optimal traffic flow and minimize congestion. Algorithms continuously assess local conditions, adjusting toll rates every few minutes based on current traffic levels. Users can pay electronically through in-vehicle units or tags provided by toll service providers or opt for post-pay billing using automatic license plate–reading technology. This ensures efficient corridor usage and streamlined payment processes, contributing to smoother and more manageable urban traffic dynamics. Implementing dynamic pricing requires a range of roadside equipment, such as cameras, toll tag readers, and weather stations, along with a sophisticated back-office system comprising a data warehouse, business intelligence processor, and toll-setting module. These components are connected through a network communications system. Dynamic pricing, when deployed broadly, can serve as a revenue stream for governments, which is especially crucial as EVs become more prevalent and impact fuel tax revenue.

One area of increasing importance to triggering massive changes in mobility behavior, often underestimated in terms of its impact if properly framed, is **the roles of private companies as well as public organizations** with significant numbers of employees based locally. Half of overall mobility demand relates to work and professional life. As commuting to work accounts for more than 50% of km traveled in cities, corporates have a big influence on private car ownership, either directly through company car schemes and funding employees' public transport subscriptions or indirectly through their pay packages.

The employer role is likely to become more significant since employee mobility is considered a source of Scope 2 emissions, an issue that has not yet been fully investigated. In the past, public transport was considered by corporates as purely the responsibility of public authorities, especially in Europe. In Asia and the Americas, corporates have been more proactive in organizing employee mobility, often to make up for a less organized PT service. For employers, taking an active role in employee mobility increases business resilience by ensuring employees actually get to the office and can help increase attractiveness as an employer.

Nudging & marketing to influence mobility behaviors

The starting point for achieving a modal shift away from private cars is to improve the maturity, accessibility, quality, and user experience of sustainable mobility modes. In addition, the physical infrastructure within which they operate, including signage, should be upgraded. Digital integration of these modes through integrated route planning, ticketing/payment, and digital way-finding can also contribute. However, in addition to physical and technical improvements, nudging and marketing techniques can also have a significant impact on mobility choices, and those are often overlooked.

Nudging refers to using behavioral, economic, and psychological insights to influence behaviors. It is considered an ethical practice as long as two conditions are met: "freedom of choice" (meaning the individual retains the right to choose their action) and "soft paternalism" (meaning the influence being exercised should ultimately be in the best interest of the individual). Mobility pattern nudging is already happening today, consciously or unconsciously within traditional route planners like Google Maps, as they often calculate travel time without allowing for the time it takes to get to your car or find a parking place, while for other modes of transportation, such as public transport or shared mobility, walking time and waiting times between modes is considered.

A 2022 study conducted at the University of Hasselt in Belgium[1] investigated the impact of nudging sustainable mobility modes in mobile route planners and MaaS apps. The study used a comparative survey, prompting users with different mobility options, while keeping all other factors the same, including origins and destinations. The study concluded that the design of a route planner or MaaS app can make a statistically significant difference in terms of mode choice. For example, the percentage of users who chose to perform a specific trip by bicycle was 12 percentage points higher when prompted via a "layout with sustainable nudging" compared to a traditional layout.

In addition to design, the importance of financing marketing campaigns with the right mobility narratives should not be underestimated. Communication campaigns that target schools and business communities and offer multimodal contextual journey planners and welcome packs for new residents can be helpful. The need for marketing is underscored by comparing the typical annual budget spent by public transport and new mobility players, which is typically a few hundred thousand euros per year, with the budget spent by the car industry, which, in some European countries, can be up to 20 times higher.

1 Borzecka, Karolina. "Nudging Sustainable Modes of Transportation in Mobile Route Planners/MaaS Apps." Hasselt University/Slim Naar Antwerpen, 2022.

There have been numerous recent initiatives encouraging companies to collaborate in the shift away from individual car ownership to green mobility. Examples include the "mobility budget" scheme in Belgium and the "fortait mobilite durable" in France.

Recommendations

We offer the following recommendations on how best to implement MDM:

- **Use a holistic and integrated approach:**
  - Develop an MDM strategy that considers a range of levers, including evaluating short-, medium-, and long-term effects. Levers should complement, not contradict, each other.
- **Consider costs and benefits systematically:**
  - Costs and benefits need to be weighed against each other, keeping in mind negative externalities and potential impacts that may vary for different users and stakeholder groups.
  - MDM works best when applied together with appropriate adaptations in mobility supply and extensions of offerings in alternative mobility modes.
  - Various low-cost measures can have high impact without major CAPEX or OPEX.
- **Tailor MDM levers for each case:**
  - The choice of levers depends on many factors, such as mobility maturity, size, and population density of the city or area; there is no one-size-fits-all solution.
  - In greenfield areas, land-use and strategic planning levers are easier to apply (e.g., by combining access and parking policy with low-traffic neighborhood design and enabling new mobility solutions).

THE ROLE OF PRIVATE COMPANIES AND PUBLIC ORGANIZATIONS IS CRITICAL TO TRIGGER A MASSIVE CHANGE IN MOBILITY BEHAVIORS

  - In existing built-up areas, adaptation of regulations is usually needed to effect short-term change, especially when trying to counteract peak hour traffic congestion. "Golden" combinations can sometimes be found through matching pricing schemes with traffic management (ITS) approaches.
- **Encourage organizations and companies to take a more active role** in setting expectations and facilitating the mobility behavior of workers, visitors, and suppliers to favor modal shift and transport demand reduction through:
  - Selecting suitable locations for offices to reduce travel distances and allow employees to work from home
  - Encouraging public transit and shared mobility proactively through employee policies and offering mobility budgets instead of company cars
  - Requiring companies to develop company mobility plans to encourage more sustainable commuting patterns
  - Setting requirements for suppliers regarding delivery consolidation and vehicle choice

MDM is a key approach toward the goal of improving urban mobility to meet the objectives of sustainability, resilience, safety, efficiency, inclusiveness, and human-centricity. It also offers good opportunities for MSPs in the form of holistic solutions and available capacities.

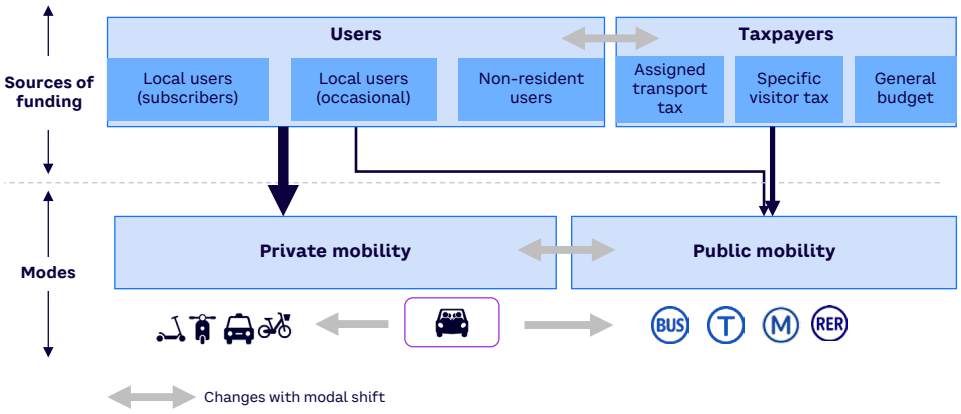
2.8 THE MOBILITY FUNDING EQUATION

Changing gear in the journey toward virtuous mobility systems also requires breakthroughs in how mobility is funded. Below we provide some background on the nature of the challenge and provide a set of considerations and recommendations on the levers that can be used to optimize the mobility funding and spending equation. We have excluded road infrastructure funding on the basis that this will remain more or less the same in cities in the future, irrespective of mobility patterns.

Mobility of individuals is funded by two sources: users and taxpayers (see Figure 24). Users belong to either households, companies, or both. Household users fund mobility by purchasing private mobility devices (usually cars) or through paying PT or shared mobility fares. Companies fund mobility by allocating a private vehicle to an employee (i.e., company car schemes), subsidizing the use of shared mobility like taxis for employees and visitors, and paying for business trips using various public modes. Taxpayers, whether individual or corporate, fund mobility through a combination of fares, tolls, and taxes, including specific transport-related taxes, visitor taxes, and general taxes. The share of each varies considerably from city to city (see Figure 25).

As Figure 25 shows, all public transport systems are subsidized, and most are more than 50% financed by taxpayers. The ratio of fares to taxes varies due to a range of factors, including cost per passenger, which can vary considerably (e.g., between busy and underutilized networks); fare levels, which is often a political choice (e.g., in Montpelier and Luxembourg, public transport is free); and non-fare revenues, such as real estate, transit retail, or advertising. The latter is usually less than 10% of the total revenues in most cities, although it can be much more significant in some cities like Hong Kong, which owns extensive retail real estate.

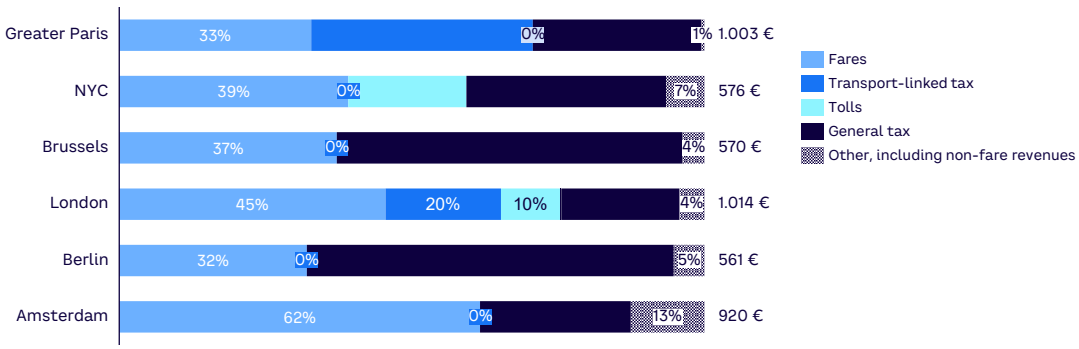
Figure 24. Schematic mobility funding flows



Source: Arthur D. Little

Figure 25. Source of public transport funding

2023 est., €/inhabitant (all modes, including suburban rail)



Source: Arthur D. Little

Private mobility accounts for a significant share of household budgets. In France, for example, a study from France Stratégie showed that for comparable types of household, the sum of mobility and housing budgets was in most situations roughly the same, but the balance between the two could change; living outside the city saves money on housing but costs more on mobility.[27] Private cars are also indirectly subsidized by the public as well, as external costs are not internalized.

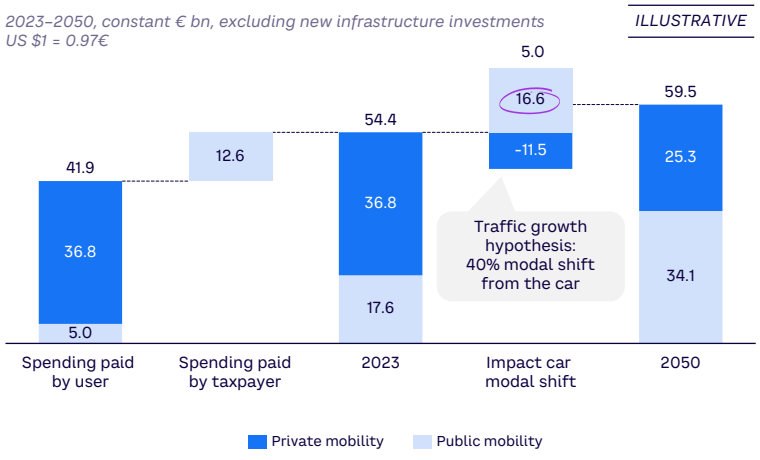
Achieving the desired modal shift away from private cars will challenge the funding model. As an illustration, and to get a sense of the additional funding needed, we estimated as a test case a 30% shift of km traveled from cars to public transport by 2050. Figure 26 illustrates this for the New York City metropolitan area. The figure shows that public mobility cost rises from €17.6 billion to over €34.1 billion, an increase of **94%.** The public mobility share of the total mobility cost increases from 32% to 55%. The analysis assumes a 40% growth in volume between 2023 and 2050, and that the shifted car-km are distributed between PT and active modes in the same proportion as today. The analysis also assumes that cost per pax-km transported in PT remains stable (in this case, €0.57/passenger-km on average for all modes). This assumption comes from the evidence of the last 20 years, which shows that in the majority of cases, cost per pax-km remains similar even with substantial growth in passenger volume.

A similar analysis for Paris shows an increase in public mobility cost from €9.6 billion in 2023 to nearly €12 billion in 2050, with the share increasing from 60% to over **70%** of the total mobility cost.

This would require new mass transit infrastructure, increased frequencies, higher capacity rolling stock, and more train-km. For new areas in suburbs and outskirts, the lower densities and required modes mean that the marginal cost of additional passengers is even higher. Cost per pax-km for shared and new mobility modes (e.g., car sharing, ride sharing) are generally higher than for private cars in less dense areas. For example, in Paris, the cost per pax-km for shared new mobility modes is €0.41 versus €0.32 for private cars.[28] For some use cases, subsidizing free-floating offerings and personal mobility devices can possibly accelerate the modal shift if no other options at a lower cost exist. DRT and free-floating devices are high-cost, and with low traffic, the ROI for the transport authority is in most cases worse than traditional PT.

Addressing climate change will require additional funding. In particular, e-vehicles, both on-street and in bus depots, will need new infrastructure. Adaptation will also require investment, as previously discussed in Section 2.1. This includes infrastructure to adapt to new climate risks, higher maintenance costs, and modifications to vehicles to adapt to extreme heat.

Figure 26. Additional funding needed for 30% modal shift by 2050 in New York City



Method

- The evolution of traffic is based on an assumption of a modal shift of the car of 30% of the km traveled in 2050 vs. today
  - Car km are then distributed between PT & the active modes in the same proportion as today, creating an increase in trips in PT + active modes & a decrease in the car
- In scenario 0, the cost per passenger-km transported in PT remained stable (€0.57/pax-km on average for all modes) insofar as the growth in PT traffic has not been accompanied by a decrease in the marginal passenger cost
- Average TCO for car is expected to decrease (at iso-situation) with EV

Hypothesis: 40% of car v-ks are transferred to other forms of mobility (up to their current proportion), ISO transport demand (number of journeys and distance)/person, ISO cost/mode
Source: Arthur D. Little

27 Le Hir, Boris, and Pierre-Henri Bono. "Dépenses de Logement et de Transport: Quels Arbitrages?" France Stratégie, 16 February 2023.
28 ADL analysis based on France's national statistics bodies (INSEE and SDES).

Key levers to optimize the mobility system funding equation

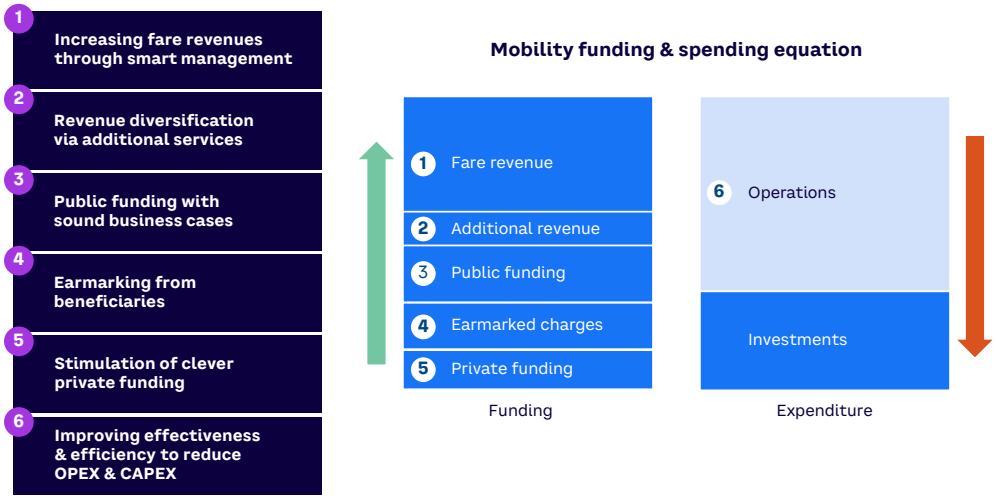
Optimizing mobility financing requires attention to all parts of the funding equation. Figure 27 summarizes the six key levers, along with considerations for the future on how each of them can be optimized.

1. Increasing fare revenues through smart management

Increasing fare revenues can involve a broad range of measures to improve the relative attractiveness of PT and shared mobility versus individual cars. The key areas for attention are:

- **Revisiting fare policies for regular travelers**
  - Fare policies are at the core of the PT funding issue since they account for 30%-50% of the total. Fares are a highly sensitive issue with political considerations often at the root of policies; for example, to what extent should transportation be viewed as a common good, how inclusive should it be, and what flexibility is there for local and regional authorities to set fare levels, considering policies at regional and national government levels? Nevertheless, users (households or companies) will save significantly by shifting from the private car to PT, implying that there is some scope to recapture some of the savings for funding PT.
  - Among the many complexities of fare setting,[29] one strategy worth highlighting is the use of subscription schemes. For example, in the Paris region, improving the penetration rate of subscriptions was a key driver for revenue increase, and there is potential for capturing an additional several hundred million euros per year with a higher penetration rate in suburbs once the offer is available. It is certainly not our intention to suggest an appropriate level of penetration for subscriptions, but it is an area to consider. In some cities, the pursuit of modal shift has already led to simplification of fare policy in the last 10 years, resulting in unified zone subscriptions (e.g., Deutschland Ticket and Pass Navigo in France). Pay-as-you-go (PAYG) schemes with capping are also worth considering for semi-regular users, although they have the disadvantage of higher working capital requirements versus subscription schemes with up-front payments.
- **Revisiting fare policies for non-regular travelers**
  - Ticket pricing for non-regular travelers has traditionally been quite static (fixed price per ride), mainly due to the limitations of ticketing systems, which have relied on chips and smart cards or magnetic tickets. The implementation of server-centric ticketing systems and open payment offers allows the easier introduction of PAYG schemes with daily or monthly capping. PAYG provides more simplicity for non-regular users and may generate an increase in the number of rides through increased mobility and/or modal shift.

Figure 27. Key levers for optimizing the mobility funding and spending equation



Source: Arthur D. Little

29 Thurmann-Moe, Lars, et al. "Public Transport Fare Models — The Right Moment to Revisit Fare Models & Help Transport Authorities Cope with Challenges." Arthur D. Little, April 2024.

There are options to capture more value from external visitors, such as special fares for airport stations (e.g., Madrid) or introducing a mandatory tax as part of the tourist tax to access public transit (e.g., Lausanne).

- **Improving the time competitiveness of public transport and shared mobility**
  - Passengers are more likely to use PT and shared mobility if it is more competitive on journey time. There are various ways to steer this; for example (see Section 2.7):
    - By slowing down the speed of private vehicles using speed limits in city centers, limited traffic zones (LTZ), or reducing the availability of car lanes.
    - By dedicating lanes to urban and interurban buses. For some urban buses, lines are still operated in a business-as-usual manner without allowing for evolving mobility patterns, such as increased use of bikes and faster population growth in the suburbs. For interurban buses, there is a tradeoff between coverage and frequency.
    - By redesigning the public transport plans to increase average commercial speeds of buses from terminus to terminus.
- **Improving the price competitiveness of public transport and shared mobility**
  - Price competitiveness can be improved by increasing the cost of driving cars in urban areas. This can be done at the local level by cities and regions; for instance, through parking fees regulation or congestion pricing/dynamic tooling systems (see Section 2.7), but also often requires the supra-regional level to intervene; for example, to increase taxation on private vehicle use to internalize some external costs.
- **Involving employers in mobility schemes**
  - There may be opportunities to encourage employers to set up mobility schemes to incentivize employees to use public transport rather than private cars (see Section 2.7).

2. Revenue diversification via additional services

As Figure 24 illustrates, there are many differences between cities in terms of funding for public transport.

Local and regional authorities should be innovative in considering additional revenue sources; for example:

- **Real estate revenues.** PT companies and authorities often own major unused or partially used real estate assets. There may be opportunities to generate revenues either directly through real estate development (e.g., Hong Kong Mass Transit Railway [MTR] Corporation's retail real estate portfolio) or through new partnerships and collaborations with retail developers in order to recapture value generated by public transit.
- **Retail and advertising revenues.** For urban mobility, these sources are typically less than 5% of revenues. There are ways, however, to increase revenue generation through retail and advertising at mobility stations and interchange hubs. Commercial partnerships can be a key lever.
- **Network and infrastructure exploitation.** There are many examples where spare or unused capacity within publicly owned network infrastructure has been let commercially to private operators. For example, in Paris, RATP is also a telecom infrastructure player through its own tower and fiber network.

3. Public funding with sound business cases

Prioritizing transport strategies and associated investments requires a systematic appraisal and objective analysis against local, regional, and national mobility policy goals, including both big backbone investments and smaller investments. This needs to include consideration of:

- **Demand.** Will the investment effectively influence positive behaviors?
- **Affordability and ROI.** How does the investment compare with alternatives in terms of reducing the overall cost per passenger at the system level, notwithstanding the public and private nature of the solutions?
- **Externalities and broader issues.** How does the investment perform versus economic, environmental, and social/inclusion issues? How does the investment compare with the public expenditure (including tax benefits [i.e., fiscal expenditure]) made, particularly on individual car ownership and use, and to what degree does that undermine the return on public investment in public transport?

4. Earmarking from beneficiaries

New targeted taxes, both transport-linked and general, may be justifiable given the increased public good being provided. Tolls and visitor taxes are obvious examples (see Section 2.6). As stated, there are multiple ways to finance public transport through taxes, which can be conveniently split into four categories:

1. **Transport-linked-tax.** Taxes directly linked to transport, such as the "versement mobilité" paid by companies in French urban areas, which directly funds the transport authorities.
2. **Urban tolls and car tax.** Tolls on bridges and tunnels, such as those in NYC that fund the Metropolitan Transit Authority (MTA).
3. **Special taxes aimed at recapturing positive externalities from transport.** Public transit offers several positive economic benefits to a city that can be recaptured through taxes; for example, an expanded labor market for companies, easier business trips and interrelations, making the city more attractive for large investments, increased attractiveness for tourists, cheaper travel versus taxis, and positive impact on the real estate market, in particular near new metro or rail stations. For example, London's Elizabeth Line was partially funded by a specific tax on offices benefiting from its development, and a similar model is applied to the Grand Paris Express.
4. **General tax schemes.** Governments can elect to allocate part of general tax revenues, including income tax and corporation tax, to fund mobility. Funding mobility from general tax budgets is clearly a political choice. On the plus side, it means that mobility needs and funding are collectively discussed alongside other priorities. On the minus side, it means that mobility budgets could be radically changed or even removed from one year to another.

5. Stimulation of clever private funding

There are several ways in which innovative public-private collaborations can stimulate greater levels of private funding into the mobility system. Some key examples include:

- **Using private capital for asset financing.** New mobility asset purchase is often difficult for the public sector. Models involving setting up profit-making private sector asset companies that purchase the assets and charge them out to operators can overcome the challenge. This concept has been used for many years in railways such as in the UK (rolling stock companies [ROSCOs]).
- **Leveraging new sources of green funding.** Mobility investments with demonstrable sustainability benefits can increasingly leverage new sources of green finance (impact financing).

Reinventing public-private collaboration

The need for a new paradigm in public-private collaboration has been a recurring theme in our Future of Mobility studies over the last decade. Fostering innovative public-private partnerships can indeed provide both financial resources and operational benefits. Making it happen requires improvement at three levels:

1. **Understand each other.** Public and private players need mutual understanding to better harmonize their roles for the good of the system as a whole. Local and regional authorities need to better empathize with private mobility provider interests (e.g., financial viability) and help improve collaboration between private players and PTOs. Conversely, private players must be willing to collaborate positively with public bodies and align with sustainable mobility policy goals.
2. **Rethink financing and subsidizing.** Mobility systems need better ways to secure finance, especially for large CAPEX investments. Public funds are often severely restricted, hence the importance of collaboration to access private sources of funding. Moreover, some private mobility services, such as car sharing and micromobility, are often barely viable, and financial support from public sources may be relevant (e.g., trip-based subsidies that positively contribute to sustainable mobility but are not financially viable for the operator).

3. **Deliver together.** Evolving requirements to dynamically manage mobility systems will imply an extended set of capabilities, which is likely to increasingly require public-private collaboration to deliver on promises; for example, to dynamically manage and optimize flows and assets at the system level ("control tower" function) or deliver enhanced multimodal passenger information and business continuity services.

The challenge to improved collaboration is that, intrinsically, public and private payers have several misaligned interests: most notably, public players are looking to deliver against policy objectives, deliver value for money, control spending, and deliver positive externalities. Meanwhile, private players are looking for an acceptable risk/reward balance, growing profit margins, improving quarterly reports, avoiding costly bureaucracy, and stability and access to finance. There are no quick fixes to overcome the misalignment, but there are some levers to make progress:

- **Identifying common goals** — and recognizing the contribution of each player toward achieving them. One key area to seek common goals is sustainability. Many mobility system investments deliver significant sustainability benefits, and increasingly there are opportunities to benefit from additional financial support through impact financing (e.g., green bonds). Global sustainable bond issuance surpassed US $900 billion in 2023, representing around 15% of total municipal bond issuances, up from only 5% in 2019, according to S&P Global.
- **Proactive sharing of interests** — making efforts on both sides to acknowledge and understand respective interests and constraints, including better signaling of needs, scale of demand, and levels of uncertainty. This helps private actors in planning for predictable growth and profit, which is something valuable in current uncertain times.
- **Governing innovation** — striking the right balance between framing (i.e., regulating) and enabling innovation to make them policy-responsive, allowing innovation to thrive through agile regulatory frameworks.
- **Governance and standards** — establishing the right governance at a system level to enable the voices of key parties to be adequately heard and represented and putting standards in place to enable data sharing while protecting the interests of the parties involved.

An example of innovative public/private collaboration around sustainability has been suggested to finance the green shift of local public transport (LPT) in Italy.[1] Italy's ambition is to achieve near-zero emissions from LPT, which means the green conversion of 95% of its urban public transport fleet by 2033. However, available public funding is insufficient in this highly fragmented market. To bridge the gap, a scheme has been proposed whereby a new company would be created ("AssetCo") to purchase and manage all LPT assets, which would then be charged out to PT operators. This would effectively separate operations from ownership and the AssetCo would be able to deliver a margin that would attract private investors to enable the necessary capital investment. Over the long term, the AssetCo would create a virtuous system capable of facilitating the continuous renewal of the circulating fleet and overcoming current fragmentation.

1 Marsella, Francesco, Andrea Visentin, and Alessandro Cutrera. "Local Public Transport: A Switch of Gear Is Needed." Arthur D. Little, forthcoming 2024.

6. Improvement of effectiveness & efficiency to improve OPEX & CAPEX

This is a broad category that includes both demand management to avoid noneffective CAPEX investment and operational cost-efficiency measures. Key areas include:

- **Transferring demand that can be addressed through active mobility, in particular for trips below 5 km.** Transport authorities may be able to save some money that would otherwise need to be invested in new bus lanes by providing bike lanes instead. A bike street costs around €0.3 million per km versus around €1 million per km for a bus lane,[30] and there is very little OPEX. This solution is particularly applicable for short trips in cities where bikes rather than buses may be the preferred alternative to cars. For example, in Lyon around 40% of trips made by car are less than 5 km, suitable for coverage by bike. Accomplishing this also necessitates the creation of safe paths and secure stops, both to prevent accidents and to deter criminal activities.

30 The French Federation of Bicycle Users (FUB)/CEREMA, 2024.

- **Managing demand better at peak hours.** PT systems are dimensioned to serve peaks that mostly occur in the morning and late afternoon; a substantial percentage of PT ridership is concentrated during peak hours. However, the advent of COVID-19 and ongoing digitalization have significantly impacted home-work ridership patterns. This may give rise to opportunities for reducing provision at certain times without affecting the overall offer. Other options exist to reduce peaks (e.g., public-private collaboration to plan remote working and promotion of active mobility). However, so far these measures have not proven as effective as was hoped.
- **Challenging the cost of current operations.** The operational costs of PT services vary considerably from one network to another, depending on many local factors related to the cost structure of the operators and how assets are managed. Clearly, driving down operational cost per passenger is a key imperative at all times. Common ways of reducing cost include greater digitalization, more predictive maintenance, better driver planning, higher asset utilization, achieving scale efficiencies, and creating synergies. In cities where there is public tendering of private operators, the tendering process can be used to apply positive pressure to operators on cost efficiency. That said, urban transport liberalization is a politicized issue and should not be seen as an automatic remedy. It has not been proven that tendered urban PT networks necessarily cost less than in-house operated networks.
- **Challenge the size of the network and modes allocated.** Often, the size of the network and the allocation of modes have developed over a long period in order to meet changing mobility demands and may be suboptimal, especially in light of the advent of new mobility services. Improving management of access and mobility demand (see Section 2.7) can yield opportunities for reducing network size and operational complexity without adversely affecting the overall quality of the offer.

Recommendations

We offer the following recommendations to address the funding and financing gap.

For local and regional authorities:

- Coordinate policies for car regulation and development of public transport to optimize modal shift, ensuring social equity and optimized financing (e.g., introduce new taxes and incentives).
- Commit to continuous improvement in the management of PT operations (whether in-house or tendered) in order to identify new levers to optimize financing and fund further development.
- Introduce new targeted taxes, both transport-linked and general, to reflect the negative externalities of private cars. However, given the allocation of accountability, note that it is often for the supra-regional level to pay a role here.
- Contemplate financial partnerships with investors to finance long-term development for fleets and infrastructure, such as mobility hubs.

For PTOs:

- Support local and regional authorities in developing the most effective offers to generate long-term returns (both in terms of transport and through diversification).
- Improve travel time. Consider more direct routes and their protection from other traffic congestion in order to improve both time competitiveness (better modal share thus better load factor) and planning efficiency (the number of trips that could be made by a single driver during a daily service).
- Innovate operations, from scheduling to maintenance.
- Work on improving load factor in vehicles, especially when expanding networks outside centers.
- Seek opportunities to enhance the cost-effectiveness of pax-km, especially in low-density areas and during off-peak times, by replacing underutilized bus services with equivalently priced trips on new mobility services (carpooling and DRT) when they offer greater energy and cost efficiency.

For private investors:

- Anticipate further financing needs from transport authorities and look for win-win public-private collaboration.
- Continue investing in new mobility services to complement public transport, working in an ecosystem play with local and regional authorities.

3. CONCLUSIONS & RECOMMENDATIONS

AN IDEAL MOBILITY SYSTEM IS VISION- AND POLICY-LED WITH SYSTEM-LEVEL GOVERNANCE

In Chapter 2, we presented the results of an objective review of eight potential solutions (concepts, policies, or services) that could contribute to creating efficient and sustainable mobility systems, including specific analysis and recommendations for each solution. Looking more broadly at each of the building blocks of the framework, we can derive some overall key insights (see Figure 28).

To recap on the framework, an ideal mobility system is vision- and policy-led with system-level governance. It offers a range of mobility modes on the supply side, matched to managed needs on the demand side, enabled via smart mobility, and provided with adequate funding.

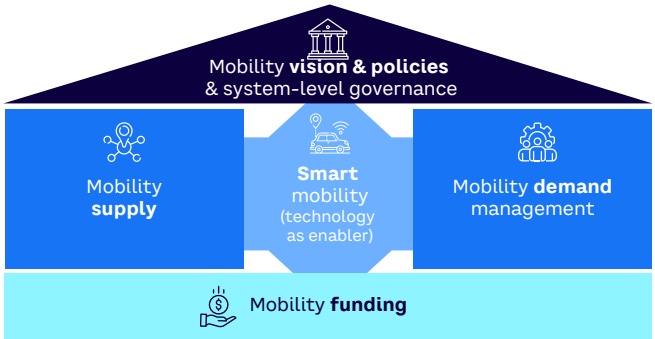
So, overall, where do we stand now, and what are the most important levers (game changers) to accelerate progress?

3.1 MOBILITY VISION & POLICY

Recent years have seen significant progress in the development of long-term mobility visions and policies and their integration within wider urban strategies. This trend is especially pronounced in Europe, driven by the implementation of sustainable urban mobility plans (SUMPs). These plans strive to establish holistic urban mobility policies that enhance quality of life and are developed through a collaborative process involving a broad spectrum of stakeholders from both public and private sectors.

This is certainly moving in the right direction, but there are still difficulties in adopting adequately integrated policies to secure progress on **climate mitigation** and a move toward net zero is still challenging. As we saw in Section 2.1, mitigation of climate change impact requires a more joined-up policy approach, whereby electrification is complemented with other key levers, in particular modal shift and transport demand reduction, to ensure that the overall impacts are maximized.

Figure 28. Framework for virtuous mobility systems



Source: Arthur D. Little

Table 2. Mobility vision and policy game changers

MOBILITY VISION & POLICY GAME CHANGERS & ACTIONS	
Combine "framing" & "enabling" measures for system-level mobility management	• Transport authorities need to move beyond their foundational **framing** activities, such as putting in place a forward-looking mobility vision & suitable regulatory frameworks & policies, toward **enabling** activities (i.e., steering & orchestrating roadmaps to facilitate the implementation of solutions that necessitate a multi-stakeholder approach to foster acceleration toward achieving system-level sustainable policy objectives)
Adopt a more joined-up set of policies to secure progress on climate change mitigation policies "toward net zero"	• Accelerate implementation of electrification strategy • Complement it with other net zero levers: modal shift & transport demand reduction to ensure that the overall impacts are maximized ("modal transition") & not limited to climate benefits alone
Reshape public spaces away from a century of car-centric transport policies	• Progressively implement "city of proximity" concepts with larger scope, differentiated functions & a stronger emphasis on measuring systemic impacts

First, we shape the cities — then they shape us. Reshaping mobility behaviors also requires reshaping public spaces away from a century of car-centric transport policies and urban planning. Implementation of the **city of proximity** urban spatial-planning concept (see Section 2.2) aims to enable more sustainable, livable, and healthier cities by considering the closeness of services needed by citizens. Overall, the concept of the city of proximity has great potential to contribute to sustainable mobility. Going forward, local and regional authorities should pursue efforts to deploy the concept at a larger scale, with possible adaptations to cater to how digitalization has changed citizens' needs for proximity and with a stronger emphasis on measuring systemic impacts.

This means moving beyond their foundational **framing** activities, such as putting in place a forward-looking mobility vision and suitable regulatory frameworks and policies, toward **enabling** activities. This includes steering and orchestrating roadmaps to facilitate the implementation of solutions that necessitate a multi-stakeholder approach, being guided by the actual problems and needs of users; for example:

- Commit to continuous improvement of the management of PT operations (whether in-house or tendered) in order to identify new levers to optimize financing and fund further development.
- Contemplate financial partnerships with investors to finance long-term development for fleets and infrastructure such as mobility hubs.
- Develop roadmaps to facilitate the setup and implementation of MaaS as well as future autonomous ecosystems (e.g., control tower role in urban centers, which will be essential for the real-time management of traffic flows and transportation assets).

Table 2 outlines the game changers and actions for mobility vision and policy.

3.2 MOBILITY SUPPLY

Improving mobility supply is about ensuring that the right mix of mobility services, modes, and infrastructures is available to meet evolving user needs, achieve sustainable mobility policy objectives, and ensure that flows of people and asset utilization are optimized within and around cities and regions.

Local and regional authorities should become smarter with transport mode allocation by developing multimodal masterplans, prioritizing transport services according to their performance and affordability. That means further development of **mass transit** as the "backbone" of the virtuous mobility system whenever traffic density justifies the investments (see Section 2.3). It also means encouraging usage of active and micromobility solutions for trips under 5 km and encouraging usage of shared and on-demand motorized mobility such as car sharing, taxi, and ride hailing for longer-distance travel. In lower-density areas, it means encouraging a mix of those solutions.

Table 3. Mobility supply game changers

MOBILITY SUPPLY GAME CHANGERS & ACTIONS	
Develop multimodal transport masterplan to better allocate transport modes, considering performance & affordability; invest in improved infrastructure for public transport, active & shared mobility	• Focus on developing public transport as the backbone of sustainable mobility whenever traffic density justifies investments, including further development of existing mobility hubs & creation of new ones • Develop & encourage active mobility (walking, cycling) & micromobility services for trips of under 5 km trips in urban, suburban & rural areas • Encourage usage of shared & on-demand motorized mobility (car or motorbike sharing, taxi & ride hailing) for occasional longer-distance travel & in lower-density areas where mass transit investment is not the most energy- and economically efficient solution
Develop partnerships between authorities & new MSPs	• Transport authorities need to cultivate new mobility as part of the menu of sustainable mobility services & foster collaboration rather than seek to regulate it • New MSPs need to look positively toward the "ecosystem play" together with transport authorities to maximize success & ensure their economic & environmental viability

New mobility services, especially shared e-scooters and e-bikes, are services with relatively high demand and are often used together with public transport to cater to door-to-door intermodal trips use cases (see Section 2.4). There also seems to be demand for car sharing and on-demand mobility services to support multimodal life use cases for users with occasional motorized mobility needs, involving using different modes for different journeys and needs, both within and outside of cities. PTOs and shared new mobility services providers thus have a shared interest in bringing about the shift away from private cars. Local and regional authorities need to cultivate new mobility as part of the menu and foster partnerships with new MSPs rather than merely seek to regulate them. That also means that new MSPs must take a greater interest in ecosystem play to maximize success and improve their economic viability.[31] Table 3 indicates the game changers and actions for the mobility supply chain.

3.3 SMART MOBILITY (TECHNOLOGY AS ENABLER)

Technological innovation is essential and can serve as a powerful catalyst to deliver on the promise of a more virtuous mobility system. However, it can also be a double-edged sword and must be carefully guided to ensure that it addresses genuine needs instead of promoting solutions in search of a problem.

The **MaaS** concept (see Section 2.5), which allows consumers to plan, book, pay for, and access various mobility services through a single digital platform, has been a prominent innovation in mobility over the last decade. It promised to facilitate a shift from ownership to usage of mobility devices and reduce reliance on private cars. However, despite some progress, the overall expansion of MaaS has been sluggish and largely failed to fulfill these promises. A primary reason is that most MaaS implementations have adopted a one-size-fits-all, technology-centric approach without adequately addressing the specific needs of users, service providers, or authorities. To meet market demands, MaaS must evolve beyond merely serving as an "umbrella app" for existing services. It should offer added value in the form of enhanced system-level functionalities that benefit both customers and cities, cater to specific target groups like tourists or private car owners, and support broader mobility goals (e.g., by suggesting routes that favor sustainable modes). Furthermore, improved collaboration within an open data ecosystem is essential for the effective realization of MaaS.

Automation of mobility services (see Section 2.6) will eventually be part of our cities and regions in the not-so-distant future, and its deployment could help solve some of today's pressing issues, such as lack of drivers, safety, and servicing remote areas. However, autonomous L4 technology is progressing slower than predicted and has still not achieved the breakthrough level needed for general application in mixed traffic. The benefits of automated mobility are not realized through individual automated vehicles but through connected vehicles in smart traffic systems. Vehicle manufacturers need to prepare technology for integrated mobility systems, not just for individual vehicle solutions. The right use cases and applications must be selected for the most positive impact at the given technology readiness rather than only aiming for the "moonshot" of AVs in mixed traffic.

31 Audenhove, François-Joseph, et al. "Sharing in Success — How Car Sharing Can Deliver on Its Potential in an Ecosystem Play." Arthur D. Little/movmi/Mobility Cooperative, February 2024.

Table 4. Smart mobility game changers

SMART MOBILITY GAME CHANGERS & ACTIONS	
Embrace innovation & technology to better address user needs & operational/system requirements	• Transport authorities need to steer & orchestrate roadmaps to enable implementation of solutions that require a multi-stakeholder approach, ensuring user- & policy-led deployment of technology rather than technology for its own sake
Frame & enable a virtuous mobility system "powered by MaaS" & anticipating development of AVs	• Transport authorities need to adopt a comprehensive approach to frame & enable a virtuous mobility system "powered by MaaS" & anticipate future development of autonomous technology: – Taking ownership of overall roadmap for MaaS/AVs, adopting a comprehensive system-level approach – Actively financing & owning certain components, such as overarching integration layers, system-level data management & MSPs regulation enforcement – Getting ready for the future necessity of a "control tower" role in urban centers, which will be essential for the real-time management of traffic flows & transportation assets • MaaS operators need to adapt their offerings to provide clearer value propositions that deliver on its real promise • Transport authorities & commercial MSPs must share information & services & work together for the greater good in an evolving open mobility ecosystem

Today, low-hanging fruit can be found both in traffic, such as automated BRT systems on dedicated lanes or remote-controlled vehicles, as well as within premises, such as automated bus driving in depots. Table 4 outlines the game changers and actions for smart mobility.

3.4 MOBILITY DEMAND MANAGEMENT

Prioritizing a shift toward sustainable mobility behaviors is crucial for enhancing transportation systems. As described in Section 2.7, our forthcoming "Future of Mobility" survey shows that the availability of alternative mobility services influences only about 30% of the potential readiness to abandon personal cars. The other **70%** needs to be addressed through effective demand management strategies.[32]

Mobility demand and access management strategies can be diverse and must be supported by thorough cost-benefit analyses that include externalities and are carefully tailored to each unique context.

Our study examined 40 potential measures and found that while some high-impact options — such as urban planning, land-use models, and dynamic tools like congestion charging — can be challenging and expensive to implement, other effective measures are more feasible if there is sufficient political will and courage. We refer to these as "sweet spots." They include **regulatory** actions aimed at reducing cars and freight in urban areas, such as low-emission zones, parking regulations, and freight transport restrictions); specific **infrastructure** initiatives like intermodal mobility hubs; and **personal travel management** measures, including smart parking solutions or MaaS apps; and marketing strategies that promote sustainable mobility. The importance of effective marketing cannot be overstated, particularly when considering the marketing spend by the automotive industry. Corporations can also play a key role in promoting sustainable mobility behaviors among their employees through initiatives such as mobility plans or mobility budgets. Table 5 shows the game changers and actions for MDM.

Table 5. Mobility demand management game changers

MOBILITY DEMAND MANAGEMENT GAME CHANGERS & ACTIONS	
Bring about large-scale mobility behavior change through the right combination of demand management measures	• Develop a comprehensive MDM strategy considering a range of levers (i.e., including regulatory guidelines, land-use & strategic planning & personal travel management-related measures) focusing on sweet spot measures with high impact & relatively low costs • Conduct effective marketing campaigns for virtuous mobility systems with the right narratives & nudging tactics • Leverage corporates to foster sustainable mobility for their employees

32 "Future of Mobility Worldwide Survey (Q4 2023)." Arthur D. Little, forthcoming, 2024.

3.5 RETHINKING THE MOBILITY FUNDING EQUATION

Expanding mass transit, especially into less densely populated areas, requires significant investment due to higher marginal costs per passenger. Similarly, transitioning to net zero and enhancing resilience require considerable financial resources for fleet electrification, new e-vehicle infrastructure, and the maintenance or replacement of existing infrastructure. Solving the financing gap will require concerted efforts on both sides of the mobility funding equation — identifying new funding sources and enhancing the effectiveness and efficiency of expenditures.

On the expenditure side, local and regional authorities must focus on maximizing the cost-effectiveness (i.e., value for money) of capital investments. This involves prioritizing funding toward the most efficient transport modes based on their usage rates and cost-effectiveness. Additionally, cultivating new mobility as part of the menu might necessitate partial public funding, especially in areas where these services enhance the overall mobility system but may not yet be commercially viable. This must be complemented by operational efficiency measures to reduce operational costs.

MOBILITY OF INDIVIDUALS IS ONLY FUNDED BY TWO SOURCES: USERS AND TAXPAYERS

Effective revenue management is crucial, particularly in fare policies, which typically generate 30%-50% of total revenues. Exploring subscription models (including within a broader MaaS framework), enhancing service appeal by improving time competitiveness, and increasing the cost of car usage are viable strategies. Diversifying to identify new sources of revenue is also relevant. Additionally, exploring all available public financing options (e.g., the European Investment Bank in Europe) and fostering innovative public-private partnerships can provide both financial resources and operational benefits. However, it is essential to recognize that revenues ultimately come from only two sources: users and taxpayers. Successful public-private collaborations require a mutual understanding and acceptance of private sector expectations for a reasonable ROI. Table 6 indicates the game changers and actions for the mobility funding equation.

Table 6. Mobility funding equation game changers

MOBILITY FUNDING EQUATION GAME CHANGERS & ACTIONS	
Optimize effectiveness & efficiency of spending: value for money, money for result	• Prioritize funding toward the most efficient transport modes based on their usage rates & cost-effectiveness. Rank modes in order of cost & use €/tCO2 saved & €/pax-km as KPIs to better allocate public money, as long as it does not interfere with the importance of protecting services of public interest that require subsidies, such as PT • Explore (partial) public funding of new mobility in areas where they enhance the overall mobility system & address public needs but may not be commercially viable (i.e., trip-based compensation) • Commit to continuous improvement in the management of PT operations (whether in-house or tendered) to identify new levers to optimize cost per pax transported
Be proactive in exploring diversification of funding sources from both user & taxpayer funding mechanisms	• Use transport authorities to coordinate policies for car regulation & development of public transport to optimize modal shift, ensuring social equity & optimized financing by internalizing external costs & capturing the value of public investment (e.g., introduction of new taxes) • Explore existing public sector loans at supranational level, including loans accessible via the European Investment Bank • Contemplate financial partnerships with investors to finance long-term development (e.g., for fleets with infrastructure) • PTOs need to explore smart revenue management (fare policy & service diversification)

3.6 PUTTING IT ALL TOGETHER — OVERALL CONCLUSIONS

Our analysis leads us to conclude that, with comprehensive implementation, appropriate funding, and robust governance at the system level, the high-impact solutions we have identified could potentially double the global share of sustainable mobility from approximately **30%** to **60%** of pax-km within the next decade (see Figure 29).

However, individually none of the solutions has an impact of more than around 15%, so there are no shortcuts. Notably, autonomous mobility has the potential to detract from the overall sustainability impact if it increases traffic volumes and leads to sustained or increased individual car ownership.

In general, time frames are short- and medium-term (up to around 10-15 years), with the exception of autonomous mobility. Most solutions have a positive impact on the various dimensions of mobility system performance although there are some compromises. For example, some aspects of demand and access management detract from inclusivity, and new mobility (micromobility, shared mobility) has potential downsides in terms of safety, inclusivity, system efficiency, and CO2 emissions.

These issues necessitate targeted measures to mitigate adverse impacts, such as offering alternative travel options.

Implementation involves a combination of regulatory measures, such as steering carbon and reallocating public space; supply measures, such as the emergence of new mobility services and new technology allowing for more connected, electrified, and autonomous services; demand management measures, such as demand and access management; nudging and marketing of shared mobility systems; and smart technology allowing for efficient and impactful sharing of data, optimization of mobility infrastructures and flows in the public interest, and public oversight of private mobility service provision to ensure accessibility, inclusivity, and safety.

While the solutions exist and the potential for transformation is evident, **the real challenge lies in putting it into action.** Making it happen in practice requires overcoming the roadblocks that have been hindering progress to date. As indicated in Chapter 2, these are multiple and significant and go back to the fundamentals of how mobility systems have operated up to now. They are rooted in issues such as how mobility systems are set to evolve, what sort of governance is in place between public and private stakeholders, and the mobility funding equation.

Figure 29. Overall impact of key solutions on sustainable mobility modal share

SOLUTIONS	Impact on mobility patterns if implemented at scale (directional)			Impact on mobility system performance & externalities				
	Impact on volume of travel	Modal share of sustainable mobility system (as % of total)[1,2]	First time to impact	Travel time/ congestion	$CO2_{eq}$	Safety	Inclusion	System (resources) efficiency
Sustainable mobility modal share — starting point		**~30%**						
City of proximity	Reduce	+10-15 % pts	Medium	Reduce	Reduce	Increase	Mixed	Increase
Demand & access mgmt. policies	Reduce		Short/medium	Reduce	Reduce	Neutral	Mixed	Increase
Climate change policies	Reduce	+10-15 % pts	Medium	Reduce	Reduce	Neutral	Neutral	Neutral
PT infrastructure (incl. intermodal hubs)	Increase		Medium	Reduce	Reduce	Increase	Increase	Increase
New mobility (micro and shared)	Increase	+5-10 % pts	Short/medium	Reduce	Mixed	Mixed	Mixed	Increase
MaaS (Level 4)	Neutral		Medium	Reduce	Reduce	Neutral	Increase	Increase
Active mobility	Neutral	+2.5-7.5 % pts	Short	Reduce	Reduce	Neutral	Increase	Increase
Autonomous mobility	Increase	-5-10 % pts	Short/high	Reduce	Mixed	Increase	Mixed	Mixed
Sustainable mobility modal share if solutions implemented at scale	-	**~60% (x2)**						

Note: (1) Modal share in terms of pax-km (not trips) in urban areas; (2) "sustainable mobility" = public transit + active mobility (walking, cycling) + new mobility services (micro, shared)
Source: Arthur D. Little

Insights from our 2024 survey of mobility leaders[33] reveal significant discrepancies between the acknowledged importance of these solutions (an average importance rating of **81%**) and the current readiness of the ecosystem to implement them (an average readiness rating below **60%**). Therefore, system-level coordination and enablement are imperative to bridge this gap and turn potential into reality — there are no shortcuts.

As mentioned earlier (see game changers related to vision, policies, and governance), to support the transition, local and regional authorities need to reevaluate their roles in shaping and guiding mobility ecosystems. Achieving this will require expanding mandates and capabilities for authorities as well as the development of more agile operational methods.

INCREASED COLLABORATION AMONG PUBLIC AND PRIVATE STAKEHOLDERS WITHIN THE EXTENDED MOBILITY ECOSYSTEM IS KEY

The solutions necessary for a transformative shift toward a more virtuous mobility future are within our grasp, with clear game changers already identified to accelerate the transition. Making it happen will demand political will, the courage to change direction, and determination to keep a steady course. Increased collaboration among public and private stakeholders within the extended mobility ecosystem is key. For this, local and regional authorities, in particular, play a crucial role in accelerating the shift — and they must be supported.

33 Ibid.

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FUTURE OF MOBILITY LAB

The Future of Mobility (FoM) Lab is Arthur D. Little's (ADL's) contribution to tackling the mobility challenge. With this lab, ADL aims to support mobility actors in shaping the extended mobility ecosystems of tomorrow and facilitating an open dialogue between mobility stakeholders. The FoM Lab gathers under the same roof as cross-industry and cross-functional professionals to support governments, authorities, mobility solution providers (public and private), and investors in shaping their roles in future mobility ecosystems. Supporting cities and investors in selecting, sourcing, improving, and engaging with micro, shared, and active mobility solutions providers and supporting the latter in improving their operations are among the key services offered to our clients.

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Founded in 1989, POLIS is the leading network of European cities and regions working together to develop innovative technologies and policies for local transport. POLIS aim is to improve local transport through integrated strategies that address the economic, social, and environmental dimensions of transport. To this end, POLIS supports the exchange of experiences and the transfer of knowledge between European local and regional authorities. POLIS also facilitates the dialogue between local and regional authorities and other mobility stakeholders such as industry, research centers and universities, and NGOs. POLIS fosters cooperation and partnerships across Europe with the aim of making research and innovation in transport accessible to cities and regions and to facilitate dialogue and exchange between local authorities, the transport research community, and the industry. POLIS also strives to provide decision makers with the necessary information and tools for making sustainable mobility a reality.

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