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Future of mobility 3.0

The Future of Mobility 3.0

Reinventing mobility in the era of disruption and creativity

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Content

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Forewords

The world is changing at a faster pace than ever. With increasing mobility demand and evolving mobility needs, mobility solution providers have to satisfy demand for services that are increasingly convenient, fast and predictable. Changes in consumer habits in recent years demonstrate that some users are prepared to sacrifice individual forms of mobility, such as the private car, in favor of other modes of transport that offer these features. This has led to the successful introduction and rapid penetration of new mobility solutions. Meanwhile, traditional mobility ecosystems have diversified, employing a wider array of actors, and the emergence of new concepts, such as Mobility-as-a-Service (MaaS), have forced them to reorganize interactions between them as they strive for the system optimum.

More than ever, the reform of mobility systems is one of the key challenges facing the world today. There are two key strategic paths that cities must take if they are to respond to environmental and capacity challenges. The first approach we have called "Rethink the system", i.e., work towards a more sustainable mobility system; and the second, "Network the system", i.e., work towards integrated mobility, with the customer at the center. In this context, all mobility solutions providers must master three key approaches simultaneously: Anticipate, Innovate and Transform.

First, it is critical for mobility solutions providers to anticipate future trends, challenge the robustness of current business models and question whether future evolutions are being correctly foreseen. Immediately after these actions have been taken, companies need to innovate by defining clear visions and identifying new business models and solutions, with a view to either reinventing themselves or finding new growth, while also improving the classical business and operating model. Finally, companies need to transform themselves by making the required changes in terms of culture, organization, ways of working and competences, in order to realize the defined vision and embark on the journey from the past to the new world.

The first global Future of Urban Mobility[1] study highlighted the mobility challenges cities face on a worldwide basis, and saw the release of the first edition of Arthur D. Little's Urban Mobility Index, which assessed mobility maturity and performance of mobility systems worldwide. Its findings indicated that there was still significant potential for improvement. The second edition of the study[2] threw further light on what was holding cities back, and, together with our partner, UITP – the International Association of Public Transport – identified three strategic paths for cities to pursue in order to better shape the future of urban mobility. It also provided public-transport authorities with 25 strategic imperatives to consider when defining sustainable urban mobility policies.

This third edition of the Future of Mobility study, published in March 2018, examines societal and technology trends, as well as new mobility solutions, and reflects on their likely impact on future mobility ecosystems. Together with our partner, UITP, it arrives at 12 strategic imperatives for mobility solution providers to consider when defining their visions and strategies to remain competitive in the short term and relevant in the long term within extended mobility systems. It also includes a new edition of Arthur D. Little's Urban Mobility Index, this time covering 100 cities worldwide, and an extended set of criteria, now increasingly concerned with innovation in urban mobility systems.

Sincerely,

François-Joseph Van Audenhove
Partner, Global Head Future of Mobility Lab

Public transport is being given new opportunities to grow and expand, as well as challenged by the emergence of new actors and technologies that have been enabled by the digital economy. Both reflect the reality of today for the transport sector, which should seize the opportunity to reinvent itself and better serve cities and citizens.

Our mobility systems are under increasing and often unsustainable pressure, reaching high levels of congestion and excessive levels of car use, at a very high cost to the economy and the health of urban inhabitants. We must address this challenge by providing more public transport solutions; the development of urban and regional rail networks in emerging countries, such in as Asia, contributes to this objective.

But beyond the provision of new lines and services, current trends require us to improve public transport services while better integrating it into urban transport systems. To do so, we need to be even more customer driven and put citizens at the heart of our strategies. We also need to think of the urban transport system as a whole and engage in integrated urban transport plans and strategies.

To achieve this, public transport is embracing current changes, particularly digitalization of businesses. We are now a data-driven industry, and should transform ourselves accordingly. This will enable us to improve our operations and maintenance activities, with an obligation to excel. Beyond that, digitalization suggests a leading role for public transport in reinventing itself and mobility, by embracing the emerging ecosystem and providing integrated mobility solutions to enable door-to-door travel.

This is possible in the framework of an integrated mobility plan, which helps not only to connect the modes, but also to integrate transport with other urban policies, in order to provide, among other things, better accessibility in cities. The Arthur D. Little's Future of Mobility 3.0 study provides useful references to support the sector in addressing these challenges.

We, at UITP, are proud to contribute to this study, which also includes some insights from our recent publications.

I hope you enjoy this reading!

Mohamed Mezghani
UITP Secretary General

1. Executive summary

Reinventing mobility in the era of disruption and creativity

The mobility landscape is being completely reshaped, and urban mobility poses a massive challenge to metropolitan authorities and businesses as well as great opportunities. The global demand for passenger mobility in urbanized areas is set to double by 2050. Meanwhile, the number of individual journeys taken on a daily basis has grown massively since 2015, thereby putting increased pressure on existing urban mobility systems. Even larger growth is expected in the field of goods mobility, especially in dense urban areas, due to the growing importance of e-commerce and the accompanying boom in demand for last-mile delivery.

The mobility industry has not been spared by the recent spate of technological advancements and innovations driven by the fourth industrial revolution. These major technological developments, including big data, artificial intelligence, the Internet of Things and the emergence of new, compact forms of energy, have thrown up a range of new mobility options. Regulation is another important driver of sustainable innovation as it is generally geared towards creating the required framework for the sound introduction of new mobility solutions, ensuring those will positively contribute to reaching the optimal system. Finally, customers' expectations for fast, reliable, convenient and individualized mobility solutions are rising as fast as the mix of transport modes and services offered to them, and this trend is likely to continue. People's mobility habits are evolving dramatically and mobility behaviors are being transformed.

Current trends and new mobility solutions, the impact of which is analyzed in this report, may lead to very different mobility ecosystems in the future. These evolutions trigger a number of opportunities, but also present key challenges for transport authorities, as well as for mobility solution providers – especially for traditional public transport operators that need to bridge the gap between this new array of demands and the services they currently offer.

Where are we now? Arthur D. Little's Urban Mobility Index 3.0

Arthur D. Little's Urban Mobility Index 3.0 is much more comprehensive than prior versions. Using 27 criteria, Arthur D. Little assessed the mobility maturity, innovativeness and performance of 100 cities worldwide. The mobility score per city ranges from 0 to 100 index points; the maximum of 100 points is defined by the best performance of any city in the sample for each criteria.

The overall results find that most cities still need to work intensively on improvements to their mobility systems if they are to cope with the challenges ahead. The global average score of the 100 cities surveyed is 42.3 out of a possible 100 points. This means that, worldwide, the average city has unleashed less than half of the potential of its urban mobility system, a state of affairs that could be remedied by applying best practices across all its operations.

Only 10 cities scored more than 50 points, out of which eight are European cities and two Asian. The highest score was achieved by the city-state of Singapore with 59.3 points, followed by Stockholm (57.1 points), Amsterdam (56.7 points), Copenhagen (54.6 points) and Hong Kong (54.2 points), which indicates that even the highest-ranking cities have considerable potential for improvement.

What is holding back change?

The conclusions from previous versions of the Future of Urban Mobility studies still hold true:

- Mobility visions and policies do not cover requirements. A lot of mature cities do not yet have clear visions of what their mobility systems should look like in the future and coherent strategies for getting there. Moreover, there is a lack of integration between transport modes, across different urban policies (environment, land planning, energy, social policy) and across regions, leading to sub-optimal outcome in terms of performance.
- The management of urban mobility still often operates in an environment that is too fragmented and hostile to innovation. Mobility systems often still do not respond sufficiently to evolving customer needs, combining single steps of the mobility value chain into integrated systems. And, despite evolution over recent years, mobility systems still often do not sufficiently bring together key players to work jointly to foster lateral learning and develop innovative mobility solutions.

In order to address future mobility challenges, cities and mobility solutions providers must first adopt more comprehensive and well-coordinated management of mobility supply and move towards a more proactive approach to demand mobility management in order to better influence behaviors in space and time. The mobility systems of tomorrow should be intermodal, personalized, convenient and connected, and encourage the usage of more sustainable modes of transport (public transport, cycling, walking) while integrating new mobility solutions and autonomous vehicles (AV).

Convergence through digitalization constitutes a major opportunity to reinvent mobility systems as they gradually evolve to embrace "Mobility-as-a-Service". Digitalization will be one of the main drivers upgrading the mobility system to a completely new level – mobility will become "a truly connected system".

The traditional division of roles in the mobility sector is being challenged today and could change dramatically in the future. Existing players are looking for ways to broaden their roles by developing add-on services to their core mobility offerings to escape what we call the "commodity trap". New players, often enabled by the digital revolution, are entering the market with the aim to gain critical positions in extended and reshaped mobility ecosystems.

Political decision-makers all over the world are incrementally responding and have developed agendas to support sustainable development, and the transport sector is one of the priority areas that is being addressed. The general target picture calls for reductions in both emissions and noise, as well as the sustainable use of materials (whether raw materials or manufactured goods), and at all levels legislation is being introduced to drive change.

But how to make it happen? Different paths and different imperatives have to be considered by public authorities and (both traditional and new) mobility solutions providers as they strive towards sustainable and integrated mobility systems to serve smart and liveable cities.

Pathways to progress and strategic directions for transport authorities

The solution for the future is an interconnected multimodal mobility system, with increased convenience and efficiency, tailored to the city's growth project and balancing economic development and well-being. The second edition of Arthur D. Little's Future of Mobility study introduced four key strategic dimensions for transport authorities to focus on as they sought to rethink their sustainable mobility policies towards networked mobility systems. These still hold true today:

- A **visionary strategy**. Cities should develop political visions and decide on objectives based on the strategic alignment of all key public and private urban-mobility stakeholders. This alignment will ensure a balance between visionary ideas and project feasibility.
- **Mobility supply management.** Cities should extend their transport offerings for citizens, with views to "delivering solutions" rather than "delivering transport". They should enter into partnerships and alliances with third parties, delivering user-friendly multimodal solutions that meet everyone's needs.
- **Mobility demand management**. Cities should define ways (incentives/penalties) to encourage people to match their behavior to the mobility mode adopted. Measures do exist, some of which are tried and tested.
- **Public transport funding**. To ensure the financial viability of public transport and its operators, assessments must be made in three areas: opportunities to derive additional revenues from aggregation of third-party services; growth in passenger numbers; and revenue collection from indirect beneficiaries of public transport.

Strategic directions and imperatives for mobility solutions providers

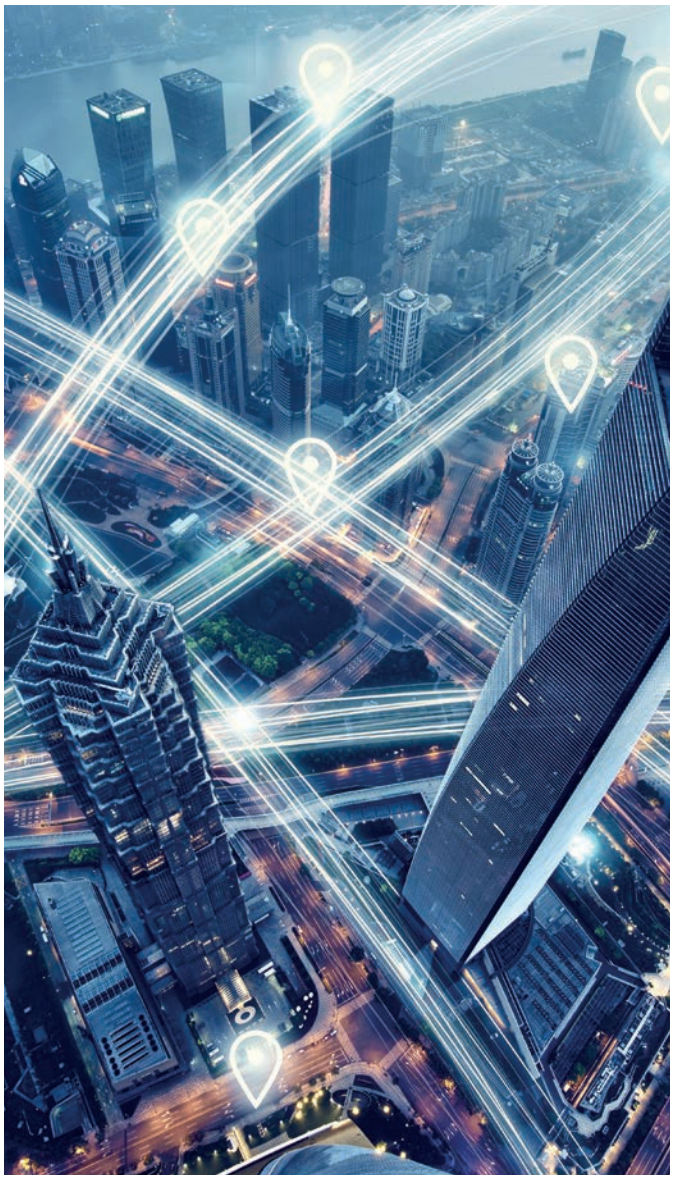
In this third edition of the Future of Urban Mobility study, Arthur D. Little and the UITP have identified **five key dimensions to be considered** by mobility solution providers seeking to reinvent themselves in order to increase their offering attractiveness, drive (or sustain) competitive advantage and, ultimately, differentiate themselves within extended mobility ecosystems in the new era of disruption and creativity:

- **Sense of purpose:** Defining a sense of purpose (or "reason to exist") by reviewing mission statements, brand platform and values, in order to secure differentiation in the marketplace. These changes should engage external and internal stakeholders alike: externally through emblematic proof along the customer journey; and internally by driving transformation at all levels of the organization.
- **Customer experience:** Increasing offering attractiveness and transforming customers into fans by better understanding mobility behaviors and customer needs; developing a superior customer experience across all touch points along the end-to-end journey; and developing a customer-centric commercial offering which takes into account differentiated customer needs.
- **Operational excellence:** Maximizing utilization of assets and improving effectiveness and efficiency of all functions across the value chain through effective long-term Capex

planning; designing and operating future-proof transport and maintenance plans; and selectively implementing opportunities via innovation and digital technologies.

- **Ecosystem integration:** Providing consumers with flexible, efficient, integrated and user-oriented mobility services through developing integrated mobility visions and transport plans; increasing collaboration across mobility stakeholders; and implementing the concept of Mobility-as-a-Service to trigger a move from personal ownership towards usage of integrated transportation solutions.
- **Transformation:** Successfully managing the company transformation in terms of leadership, culture, organization and talent management to remain competitive in the short term and relevant in the long term – a shift that involves a willingness to embark on a journey from the "era of productivity" to the "era of creativity".

Arthur D. Little and the UITP elaborate further on those dimensions and identify 12 imperatives for mobility solutions providers to consider when defining their sustainable visions and strategies. The study also includes case studies of mobility solutions providers demonstrating good practices.



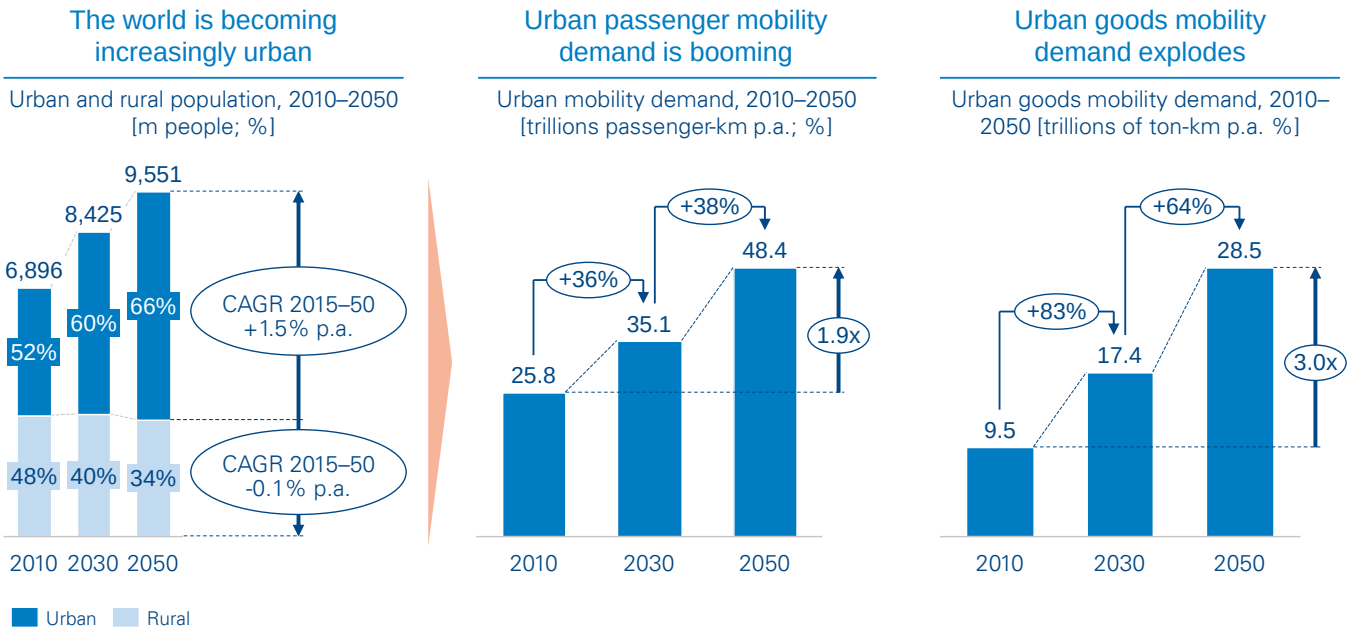
2. Reinventing mobility in the era of disruption and creativity

2.1. Current status – Rules of the game are changing

Mobility demand is booming. The mobility landscape is being completely reshaped, and urban mobility poses a massive challenge to metropolitan authorities and businesses, as well as great opportunities. The global demand for passenger mobility in urbanized areas – in terms of passengers-kilometers per year – is set to double by 2050. Meanwhile, the number of individual journeys taken on a daily basis has grown massively since 2010, thereby putting increased pressure on existing urban mobility systems. Even larger growth is expected in the field of goods mobility, especially in dense urban areas, due to the growing importance of e-commerce and the accompanying boom in demand for last-mile delivery. (See Figure 1.)

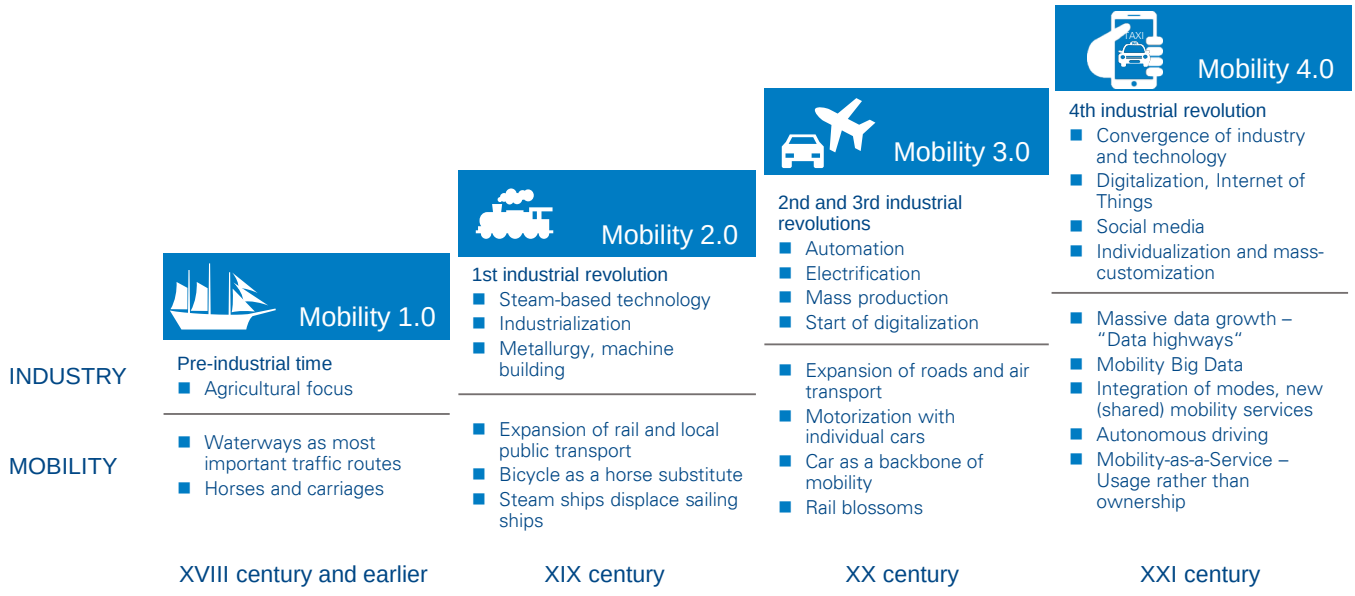
Neither has the mobility industry been spared by the recent spate of technological advancements and innovations driven by the fourth industrial revolution. These have thrown up a range of new mobility options.

Figure 1: The future of mobility will be urban



Source: UN Department of Economic and Social Affairs, OECD/ITF, Arthur D. Little

Figure 2: Mobility is being redefined again, driven by the 4th industrial revolution



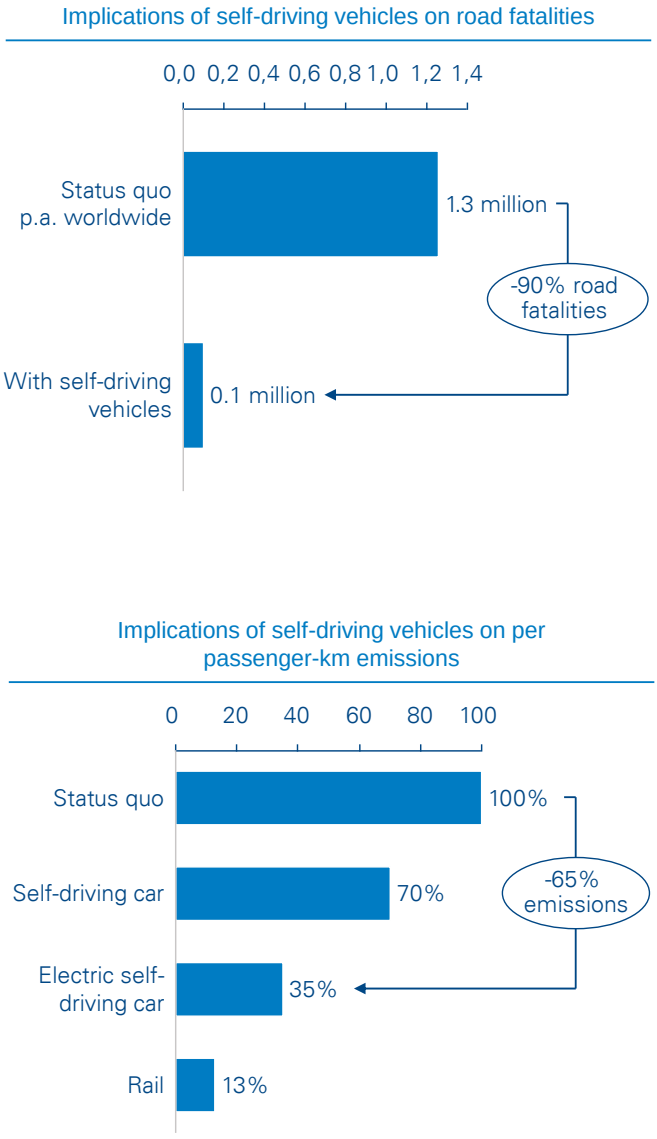
Source: Arthur D. Little

These major technological developments include big data, artificial intelligence (AI), the Internet of Things (IoT) and the emergence of new forms of energy. The growing efficiency of the algorithmic processing of big data, offered in particular by artificial intelligence, is increasingly providing data-driven insight that foster creation of new mobility services, such as real-time journey optimization, which allow more efficient use of existing mobility assets. The great leaps made in artificial intelligence in recent years are a revolution in itself, as it has enabled the emergence of autonomous vehicles. Internet of Things technologies are also significantly influencing the future of mobility as they introduce a new, continuous communication channel between mobility stakeholders, increasing the ability to capture and share data. Several recent studies anticipate annual double-digit growth of the Intelligent Transport Systems (ITS) industry across all its market segments – passenger information systems, smart traffic control, parking management systems, etc. Finally, the production on a massive scale of new, compact forms of energy, such as lithium-ion batteries, will also allow for economies of scale and extended journey range, which will drive the adoption of electric mobility solutions.

Regulation is an important driver of innovation, as it is generally geared towards creating a framework for the introduction of more sustainable mobility solutions. In recent months, several cities and nations have adopted regulations that will ban sales of cars with petrol and diesel combustion engines in the long term, and gradually replace them with alternative engines (electrical, hydrogens): the Netherlands by 2030, Norway by 2035, and France and Great Britain by 2040. China has committed itself to banning production of petrol and diesel cars "in the near future" and, starting in 2018, automotive Original Equipment Manufacturers (OEMs) in China will be obliged to ensure that at least 8 percent of their new-car sales are electric or plug-in hybrids. Starting in 2020, that figure will rise to at least 12 percent. The high growth rate of the market for cars with electric engines is a vivid indicator of this trend. In 2015, there were around 1.2 million electric vehicles worldwide. By 2025, there are expected to be 26.2 million[3]. Similarly, most cities and nations in the developed world have adopted policies to better integrate new mobility modes (such as car-sharing and electric bikes) into urban areas and regulate parking capacity and usage.

If properly regulated and priced, fully autonomous vehicle systems have the potential to significantly reduce traffic jams, pollution and consumption through optimized real-time route planning, shared-use and space-efficient driving. They will also provide individual mobility to people without driving licenses (e.g., children, the elderly and people with disabilities), and significantly increase both travel comfort and efficiency. On the other hand, it may in some cases threaten the jobs of professional drivers, put in doubt the durability of some existing modes of transport, and raise a number of challenges in fields such as data protection and ownership.

Figure 3: Expected impact of SDVs on road fatalities and CO_2 emissions



Source: Arthur D. Little analysis, multiple studies

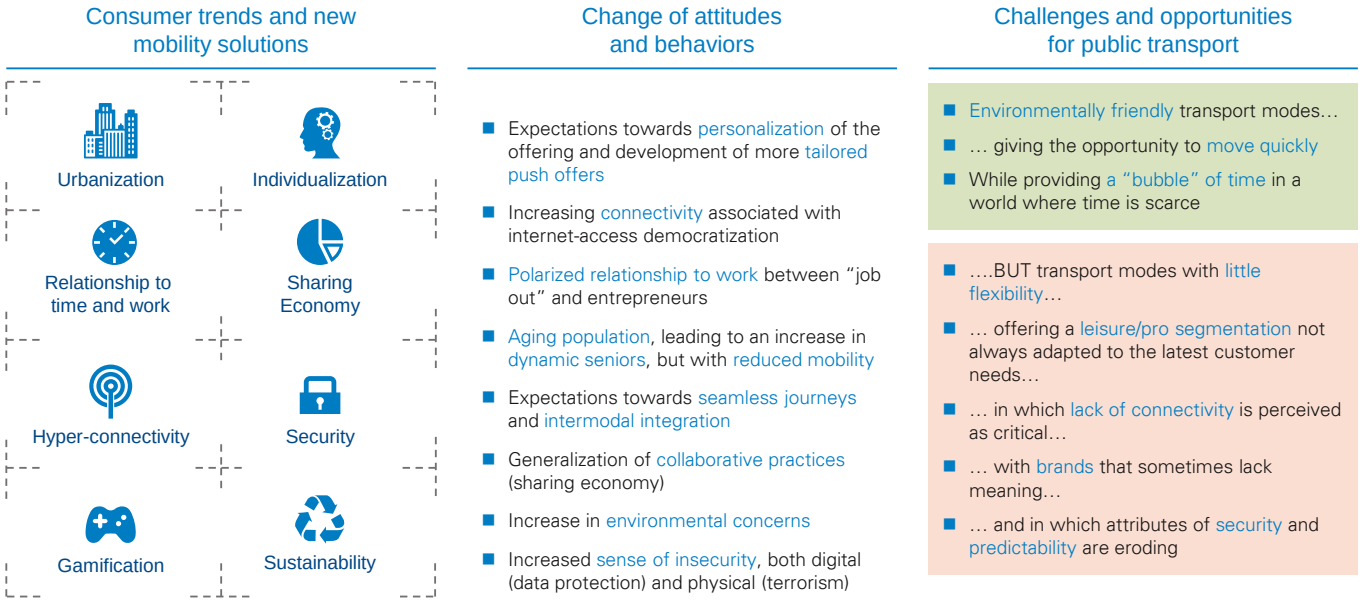
Societal mutations are driving change in customer expectations and mobility usage and behavior

Customers' expectations for fast, reliable, convenient and individualized mobility solutions are rising as fast as the mix of transport modes and services offered to them, and this trend is likely to continue. A significant change in the behavior and needs of consumers has been observed over the last years.

- People's mobility habits are evolving dramatically: the number of journeys they take is increasing, the frequencies and amplitudes of these trips are changing, and even the purpose of mobility is evolving beyond the traditional function of work/school commuting).
- Driven by technology, mobility behaviors are also being transformed. A growing number of hyper-connected consumers expect customization and control, and there is increasing polarization of behavior between "deal hunters" – with little brand loyalty – seeking the cheapest travel option, and experiential/aspirational consumers who place more value on the quality of their journeys.
- Established mobility systems are also under pressure from an increasing variety of socio-demographic categories (e.g., seniors, who travel more these days), and this has driven demand for multimodal mobility. The average age will rise from 30.1 in the year 2016 to 36.2 in 2050[4]. An aging population will require mobility services that are much more tailored to individual needs – the question of the last mile cannot be left open any longer. The access to mobility services must be easy, the travel chain must not be interrupted, and additional services designed to make the traveling experience smoother will be requested.
- The traditional model of car ownership is in decline, making way for a new sharing culture. The current generation of 18–25-year-old customers is increasingly willing to share, and more concerned with usage than ownership and multi-modality, as long as the various offerings are meeting their individual needs.

These evolutions trigger a number of opportunities, but also present key challenges for mobility solution providers – especially for traditional public-transport operators that need to bridge the gap between this new array of demands and the services they currently offer. (See Figure 4.)

Figure 4: Evolution of customer expectation and mobility usage and behavior



Source: Arthur D. Little

2.2. Mobility outlook – Mobility ecosystems of tomorrow

Current trends and new mobility solutions, the impact of which is analyzed in this report, may lead to very different mobility ecosystems in the future. These evolutions trigger a number of opportunities, but also present key challenges for transport authorities, as well as for mobility solution providers – especially for traditional public transport operators that need to bridge the gap between this new array of demands and the services they currently offer.

To which extent will the introduction of self-driving private and public vehicles contribute positively to the evolution of mobility ecosystems, and what will be the impact on the demand for car sharing and traditional rail and urban public transport?

Over the last few years, the number of studies looking at self-driving technologies and their impact on the future of mobility increased tenfold. No one now disputes that we are on the brink of a revolution in mobility. The only question is when the new disruptive technologies will be fully embedded into mobility systems (meaning not only over short distances, at low speeds, and in segregated lanes). A growing number of experiments, conducted in real-world conditions, are taking place around the world, with the different players seeking to prove the superior effectiveness of their technology and promote vehicle learning via artificial intelligence. The United States in particular, which benefits from more flexible legislation, has hosted multiple tests. Despite stronger regulation in Europe, tests started there in 2015, largely driven by the European initiative CityMobil2.

The ride-hail company Uber piloted autonomous taxis in Pittsburgh and Phoenix (US), and its rival, Lyft, recently launched its first self-driving car pilot, developed by the start-up NuTonomy, to pick up passengers in Boston's Seaport district. Since October 2017, Waymo, the autonomous vehicle division of Alphabet (Google's parent company), has been operating autonomous minivans on public roads in Arizona without a safety driver behind the wheel.

Several initiatives involving self-driving public transport have been initiated in recent years. In 2017, PostBus launched an autonomous bus experiment with real-life passengers in the agglomeration of Saillon-Valais in Switzerland, as it sought to craft a new model in a competitive and crowded marketplace. Since 2015, EasyMile has been testing its EZ10 driverless electric bus at over 50 sites in 14 countries spread over Asia, North America, the Middle East and Europe. In 2016, Keolis Group invested several million euros in Navya, a leader in the construction of autonomous shuttles. Similarly, Transdev entered into a strategic partnership with Delphi Automotive, a supplier of vehicle technology, to accelerate the use of autonomous public-transit shuttles and pods on open roads and city streets. The operators and their partners are currently conducting several autonomous shuttle trials in France and plan to expand their activities into other countries in 2018.

Some cities have set ambitious goals. The Government of Singapore recently initiated the development of principles to govern an autonomous mobility system, and is already allowing tests of AVs of levels 4 and 5 with passengers inside. The Road Transport Authority (RTA) in Dubai has launched Dubai Autonomous Transportation Strategy, stating that – by 2030 – 25 percent of all trips in Dubai will be driverless. If opinions still differ on how autonomous vehicles will arrive on the roads, especially with regard to level 5 operations in real traffic situations, there is no doubt the timeline is getting more concrete, as several major car manufacturers have announced industrial production of shared autonomous vehicles starting in 2020.

According to a recent study, the car-sharing market is expected to increase, with an annual growth rate of 34.8 percent until 2024[5]. The development of self-driving vehicles could well be a major shot in the arm to the take-up of car sharing. According to World Economic Forums projections[6], 42 percent of all self-driving cars (or 2–8 percent of the total global car fleet, depending on the scenario under examination) in 2030 will be shared and, in 2040, 53 percent of all self-driving cars will be shared (7–39 percent of total global car fleet, depending on the scenario).

Case studies: Dubai as a test bed for autonomous driving and new mobility

Dubai Future Accelerators program was launched in 2016 by His Highness Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, Crown Prince of Dubai and the Chairman of Dubai Future Foundation, under the directives of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Ruler of Dubai. It is a unique program for cutting-edge entrepreneurs, in partnership with the government of Dubai, to use the city as a living test bed for creating solutions to the global challenges of tomorrow.

In that context, the emirate has set itself a highly ambitious goal: by 2030 all types of self-driving vehicles – trains, robotaxis, buses, boats and private autonomous cars – should represent 25 percent of the modal split. And the first fruits of Dubai's autonomous mobility strategy are already visible:

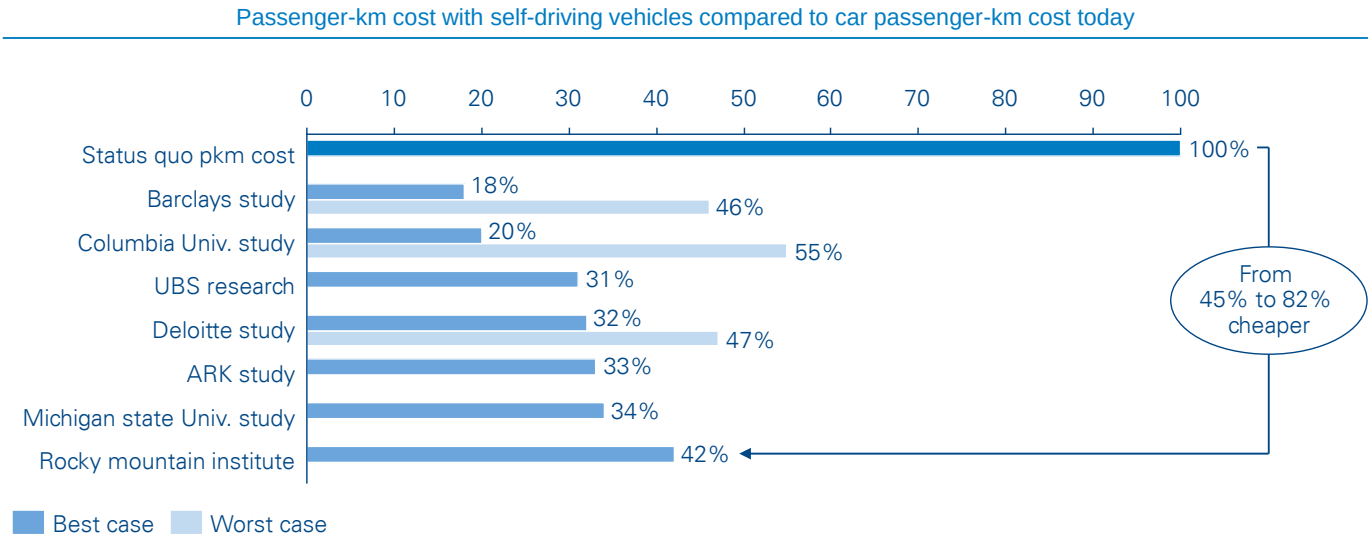
In 2017, RTA introduced new flying drones (operating on fixed routes with qualified pilots manning the craft). The proof of concept was successfully delivered, and the Autonomous Air Taxis (AATs) are expected to become the world's first "self-flying taxi service". The AAT is environmentally friendly, powered by electricity, and the prototype version has a maximum flight time of 30 minutes, at a cruising speed of 50 km/h (31 mph) and a maximum airspeed of 100 km/h (62 mph).

In early 2018, RTA signed an agreement with American company Next Future Inc. to develop the world's first autonomous pods units, named NX1. The prototypes of these units, which have average speeds of 20km/h and capacity of 10 riders (six seated, four standing) run on a virtual preconfigured and programmed lane and can be coupled to each other and detached.

RTA and HERE Technologies have signed a memorandum of understanding on a long-term technology collaboration, with the aim of mapping the city with high-definition technology and deploying newly available location technologies in the development of data infrastructure to support safe, sustainable and efficient autonomous transportation.

Finally, another of Dubai's futuristic visions is Hyperloop transportation. Los Angeles-based company Hyperloop One plans to introduce the world's first operational Hyperloop system, which would see passengers traveling between the emirates of Dubai and Abu Dhabi in special pods at 1,200 km/h. This means a journey from Dubai to Abu Dhabi would only take 12 minutes, compared to the current journey time of two hours. Hyperloop One has said it could have an operational system built in the UAE in the next five years.

Figure 5: Expected impact of SDV on passenger cost per kilometer

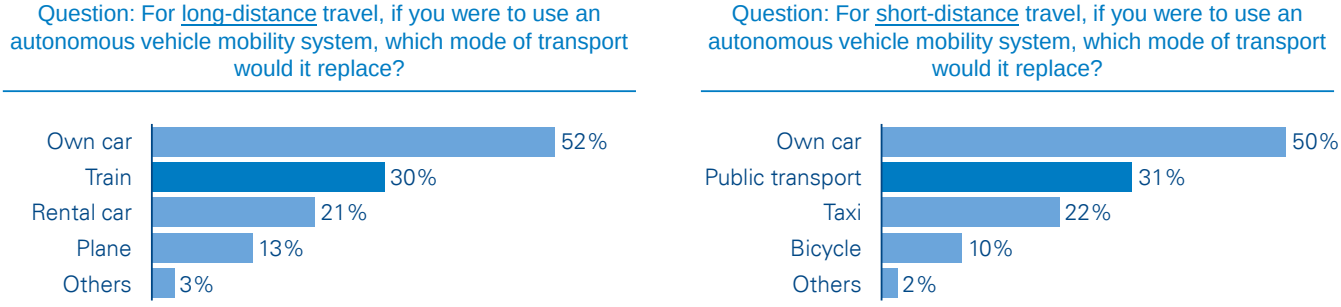


Source: Multiple studies, Arthur D. Little analysis

Apart from the fact that self-driven vehicles will decrease mobility costs and increase the productivity of infrastructure thanks to the absence of associated driver "costs", both production and maintenance costs are expected to be much lower than for traditional motorized transportation solutions. (See Figure 5.) Current studies[7] report that passenger-km cost will be 45–82 percent cheaper. The vehicle itself will be 10–20 percent cheaper. And the operating cost will be 20–30 percent less. Further savings will accrue from the sharing model (the more people sit in a car, the less km-cost per passenger). However, to what extent will the introduction of autonomous driving contribute to the performance of mobility ecosystems?

From a socio-economic perspective, fully autonomous vehicles will have a revolutionary effect, especially in cities. A customer survey performed by Arthur D. Little confirmed that owners of self-driving cars would expect to use their private individual vehicles significantly more often once autonomous features were available, thereby adding traffic to the streets. The study also highlights the prediction that half of the future users of autonomous vehicles will be current private-car drivers, and that, in an unregulated environment, self-driving vehicles could very well capture a significant amount of the traffic – both short and long distance – that is today carried by public transport. (See Figure 6.)

Figure 6: Expected impact of SDVs on modal split



6,500 respondents in 10 countries
(China, France, Italy, Germany, Japan, South Korea, Spain, Sweden, UK, USA)

If incumbent operators don't disrupt themselves they will be disrupted by others

Source: Arthur D. Little, Future of Automotive Mobility

According to the PTx2 ambition of the UITP, the public-transport share in the modal split would need to globally rise from 16 percent (baseline 2005) to 32 percent on average by 2025. A recent study performed by McKinsey Research Institute[8] estimates that by 2030, 31 percent of total traffic volume will be carried out by self-driving cars, with an associated decrease in public transit of 20 percent. While this decrease is expected to be offset by the overall increase in mobility demand, this would still mean limited growth in the coming years for public transport.

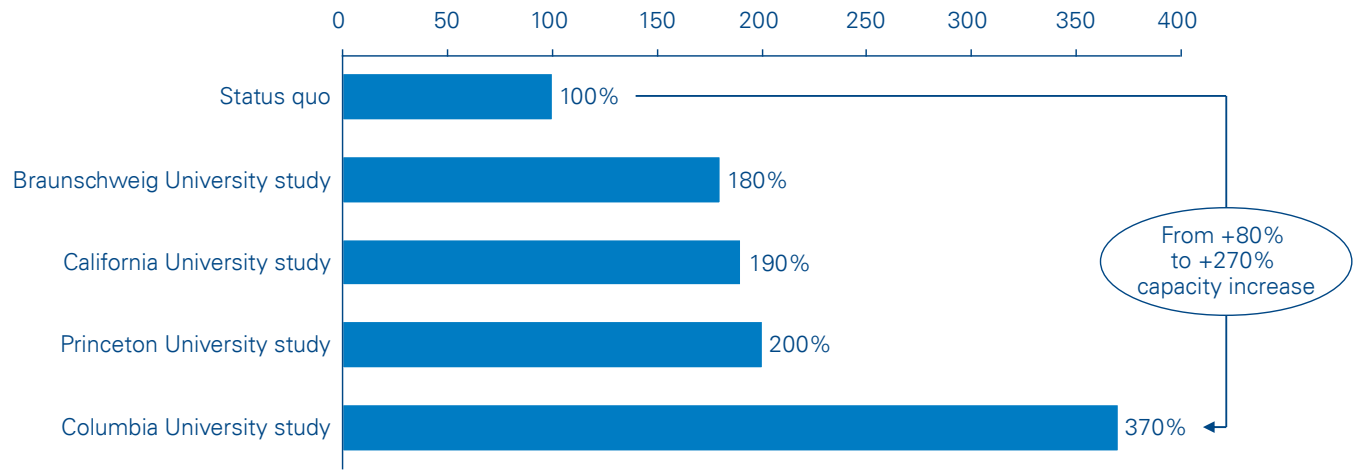
This analysis, however, does not take into account the likely effect of new regulations and the ability (or not) of the public transport industry to reinvent itself by taking advantage of autonomous vehicle technology and integrating self-driving mobility services into their offerings. In a recent policy brief[9], the UITP stated that the public-transport industry should remain the backbone of intermodal journeys in the future, while shared autonomous robotaxis and on-demand shuttles should serve as feeders to public transport trunk lines, thus resolving the first- and last-mile issue when it comes to door-to-door mobility. This would add up to a versatile and highly efficient integrated public-transport system.

In addition, autonomous vehicles could make a major contribution to mobility in rural areas by reconnecting individuals who live in the countryside. Even though an increased number of people are moving to cities, a high percentage of the population live in rural areas that are often not well covered by traditional public transport. An increase in public transport coverage through autonomous public transport could improve accessibility and well-being (e.g. for elderly people that are not able to drive a vehicle themselves) as well as reduce dependencies on private car ownership. Next to the evident social and environmental benefits, self-driving vehicles could service mobility demand in rural area much more efficiently and with higher service level that traditional public transport[10]. Moreover, given simpler traffic situation, the country side is also to be considered a relevant test-bed for autonomous mobility solutions.

How will new mobility solutions affect capacity requirements of road infrastructure?

Studies[11] report that the capacity of road infrastructure could be increased through digitalization and self-driving cars by 80–270 percent. The cost-savings generated in this way, coupled with the superior safety levels of self-driving vehicles, could increase the attractiveness of road transportation versus other modes of transport for both short- and long-distance trips.

Figure 7: Expected impact of digitalization on highway throughput rate



Source: Multiple studies, Arthur D. Little analysis

What impact will autonomous vehicles have on city planning and real estate?

According to available projections, shared autonomous vehicles or robotaxis would make up a significant part of the total mobility fleet in the future, and considerably decrease passenger-kilometer cost. Automotive and transportation are not the only industries that will be disrupted by this development. Autonomous mobility is also expected to significantly affect city planning and considerably change the laws of real-estate markets.

First of all, a self-driving smart city would not need as many parking spaces as cities need today, and be able to make better use of areas freed up from parking. The OECD's simulation model[12] showed that in a city such as Lisbon an area equivalent to 210 football fields could become available. Many existing garages could be converted to retail facilities, for example. The demand for on-street parking will decrease drastically too. On the other hand, cities will have to provide large-scale pick-up and drop-off zones for robotaxis.

In the years to come, we expect a series of pilot projects worldwide to illustrate the advantages of autonomous mobility for city planning. Some futuristic plans have already been produced that show how a self-driving city could look, with streets replaced by multimodal shared spaces, and parking spaces by parks. There will be no more separated pavements, and waste disposal systems will be installed underground. New smart city planning approaches aim to create high-quality living spaces without sacrificing the land-use mix to serve the needs of individual motorized transport. Google's Sidewalk Labs recently announced a promising lighthouse project in Toronto's greenfield neighborhood, Quayside. In 2018 it proposes to publish a concrete plan showing how land use, mobility, and other smart city elements of this innovative district will be organized.

While the availability of good public-transport services in any given urban district will still influence real-estate prices, property prices in neighborhoods without proper public transport services should also rise, driven by their improved accessibility due to autonomous mobility. As commuting will get cheaper and easier, many current city dwellers will decide to move to suburban areas, a trend that will lead to a decrease in city-center house prices and an increase in the value of suburban residential real estate. Thus, the price gap between the center and the periphery will get smaller. However, the disruptiveness level of autonomous mobility on residential real estate will not be the same in all cities, as the shortage of space in urban areas with mature public-transport systems, combined with the need for high-capacity means of transport, will "protect" mobility and house markets from large-scale disruption.

But not all segments of real-estate markets will be equally affected by the autonomous vehicle revolution. Prices for commercial property in city centers are likely to increase as it becomes more accessible. Retail and entertainment destination locations, such as large mobility hubs and shopping centers, are also likely to profit from being more accessible to autonomous, shared, electric vehicles. At the same time, retail real estate, in the form of non-destination outlets such as convenience stores, is likely to lose value, as the importance of physical proximity will diminish.

How will digitalization and new mobility solutions affect parking-capacity requirements?

Smart parking is considered a core component of smart-city initiatives, and parking facilities will become increasingly integrated with other mobility solutions. The smart-parking industry in Europe and North America is currently valued at $7 billion, and expected to grow at a CAGR of 18 percent, to reach $44 billion in 2025[13].

City governments, particularly in Europe, are progressively introducing mobility demand management measures in a bid to change travel habits. In furtherance of this goal, several metropolitan authorities have combined a reduction in the number of parking places in the city center with an increase in the prices charged to occupy them. We expect this strategy to become more and more common in the future. The demand for parking spaces in the inner city is also likely to be reduced by the fact that cost-conscious self-driving cars will target cheaper parking in the suburbs. Several simulations have predicted that the introduction of self-driving cars will require between 30 percent and 80 percent[14] less parking, as cars will be better utilized and less time will be spent searching for parking spaces. On the other hand, the battle for curb-space access among the different services and vehicles is likely to increase.

What is the expected evolution of bike-sharing schemes, and to what extent will they have a positive impact on the performance of mobility systems?

Bike-sharing services have been in existence for more than 50 years, having been introduced in Amsterdam in 1964. But the first signs of a real uptake in bike-sharing were not observed until 2007. While successful city-bike programs started in Vienna (2002) and Lyon (2005), it was not until the Velib program started in the French capital, Paris, in 2007 that bike-sharing took off. It exceeded all expectations and triggered interest worldwide, inspiring many cities to introduce this environmentally friendly mobility service shortly afterwards.

In 2011, Arthur D. Little's Urban Mobility Index 1.0 revealed that 34 cities out of the 66 surveyed offered bike sharing schemes, with an average penetration rate of 344 shared bikes per million citizens. Six years later, the Urban Mobility Index 3.0 showed that 81 cities out of 100 surveyed had bike-sharing schemes, with an average penetration rate of 3,988 shared bikes per million citizens – an increase close to a factor of 12 over a six-year period, which peaked in 2016.

So what was the catalyst for this bike-sharing boom? The current bike-sharing revolution started in China. The game-changer was the same innovation that stoked the rise of the car-sharing industry: a move from station-based to free-floating models. Free-floating, or so-called "dockless", bike-sharing schemes made it possible to pick up or drop off bikes virtually anywhere by locking and unlocking them via an app. To power the locks, narrowband IoT networks are used.

The biggest players in the global market are Chinese start-ups Ofo, with 10 million bikes spread among 250 cities worldwide, and Mobike, with 8 million bikes in 200 cities. Another big player is Singaporean start-up oBike, which has a fleet estimated at more than 1 million bicycles operating in 60 cities. The Chinese companies are valued at about $3 billion each, with Ofo investors including the e-commerce giant Alibaba and "Chinese Uber" Didi Chuxing, and Mobike's shareholders including technology giant Tencent and top electronics manufacturer Foxconn. Both start-ups together currently account for about 90 percent of the Chinese bike-sharing market.

It is widely accepted that the business case for bike sharing is not as clear cut as it is for other mobility services. User fees are not sufficient to cover operating costs, and operators tend to generate additional revenues from advertising, as well as receiving subsidies from local government. Despite these income streams, some bike-sharing schemes still operate in the red.

According to leading bike-sharing providers, their ultimate goal is to create a global sharing platform, with bike-sharing operations only the first step on the way to this goal. Thus, a change in their business model can be expected within a few years. One possibility is for them to enter other mobility markets, such as car sharing, or to launch e-hailing services using their existing critical mass of bike-sharing customers. Yet another option would be to become a mobility market aggregator and offer their platforms to other mobility-service providers. Ofo and Mobike already provide more rides per day than taxi companies in many Chinese cities, and in some cases their ride totals even outnumber subway rides. This could make Ofo's and Mobike's apps a good starting point in the creation of shared mobility platforms.

What will be the impact of smart-traffic management and the Mobility-as-a-Service platform in decreasing congestion through optimal allocation of private and public transport modes?

Integrated mobility platforms have the potential to increase the share of public transport and sustainable mobility modes in the modal split. There is no strong, empirical evidence for this yet, given that – up to now – usage rates have been too low to support meaningful conclusions. But the success of pilot schemes in Gothenburg (UbiGo) and Vienna (Upstream, Wiener Linien), as well as a recent survey among Whim users in Helsinki, indicates that integrated mobility platform users benefit from a significant increase in the use of public transport, walking and cycling. A year ago, several experts predicted that integrated mobility platforms would mainly remain in "marketing mode" until 2025. However, the success of public and private Mobility-as-a-Service platforms, such as Upstream, Moovel, Hannovermobil and MaaS Global, has renewed interest in MaaS. These developments, plus the emergence of interest groups advocating a speedy overhaul of regulation to ease the development of Mobility-as-a-Service platforms, are likely to accelerate development significantly, and MaaS may well become the next big thing in the urban mobility sphere. Please refer to chapter 5.4.4 of this report for further insight on this topic, as well as reflection on future MaaS development scenarios.

What happens if rail unleashes the potential of digitalization? What if it doesn't?

Rail systems could increase their line capacity through digitalization by as much as 40 percent via advanced Traffic Management System[15]. The greatest potential for improvement lies in countries where rail infrastructure is outdated. Furthermore, urban settlement structures (smart cities) will become key to any move to "tie" customers to rail. If rail

operators manage to develop appropriate mobility hub networks and transit-oriented-development communities, with a car-light approach, people will remain dependent on rail, at least for long-distance trips.

Those rail operators that work on differentiating their commercial offerings, increasing customer satisfaction through higher quality of operation and updating their operating models through digitalization, could sustain good competitive positions. However, in some cases, a wake-up call will be required if rail-infrastructure managers and operators are to reinvent themselves sufficiently to remain competitive in the future.

Finally, who will be the next disruptor of the transport industry? What will be the impact of new mobility solutions such as Hyperloop and self-flying cars?

We don't know. What we do know is that disruption can happen very fast. Uber was established in 2009 and, Lyft in 2012, and after only a few years of operation, they have taken over 30 percent of taxi rides[16] in many cities and caused several traditional taxi companies to go bankrupt. This trend will continue, as the global market share of traditional taxi operators is expected to be halved by 2030.

The next evolutionary step in transport systems could involve the Hyperloop and self-flying cars – if they can be developed successfully. According to Elon Musk, the founder of SpaceX and Tesla, who first came up with the Hyperloop concept, construction of the Hyperloop would be 10 times cheaper than building a railway line on the same route. If his costing estimates are correct, its impact on long-distance rail could be very disruptive indeed.

The mass production of flying cars would theoretically solve all capacity problems, as – instead of being restricted to roads or railway lines – they would be able to fly on a virtually infinite number of different layers. Over a dozen companies are currently hard at work on making vertical take-off and landing (VTOL) aircraft a reality, and several producers have even got to the point of testing prototypes. Some claim they may begin mass production as soon as 2020.

In 2017, Dubai's RTA introduced flying drones (operating on fixed routes with qualified pilots manning the craft), and taxi services such as Uber are looking to develop similar machines. Should they succeed, flying taxis could soon become the norm.

"Future of Automotive Mobility"

In the hundred years or so since the Model T Ford, the world's first mass-produced car, rolled off the production line, the automobile has been blamed for many of the most serious issues facing the world's leaders. As societies grew increasingly urbanized and wealthy, so the number of private cars increased and the pollution and congestion they caused became a global problem. Technological development seems to offer solutions: electric mobility leads to much cleaner mobility, car sharing will decrease the number of vehicles in use worldwide, and autonomous driving will help boost the capacity of roads – whether urban streets or intercity highways. Really?

To assess the impact of those key trends, Arthur D. Little conducted a 360-degree study incorporating perspectives from customers, industry players and regulators[17]. Here is our conclusion: transformation of the automotive industry is no longer driven by customers alone – regulation will play a key role. In light of growing urbanization worldwide, national governments and city authorities – as the main regulators of mobility solutions – are starting to get stricter in a bid to maintain environments that are worth living in. That said, they will need to incorporate a number of key customer requirements into their concepts, including:

- The majority of people worldwide see ownership of a car as highly important – mainly due to status.
- The potential of electric mobility is limited by the higher purchase price of electric cars compared to models with internal combustion engines, as well as the associated

issues of battery life (thus journey range) and insufficient charging infrastructure.

- The fact that autonomous vehicle concepts (mostly) will be introduced to a brownfield environment with legacy car parks, and pedestrians and customers are willing to accept autonomous and shared concepts as an additional mobility option, not necessarily to replace private cars.

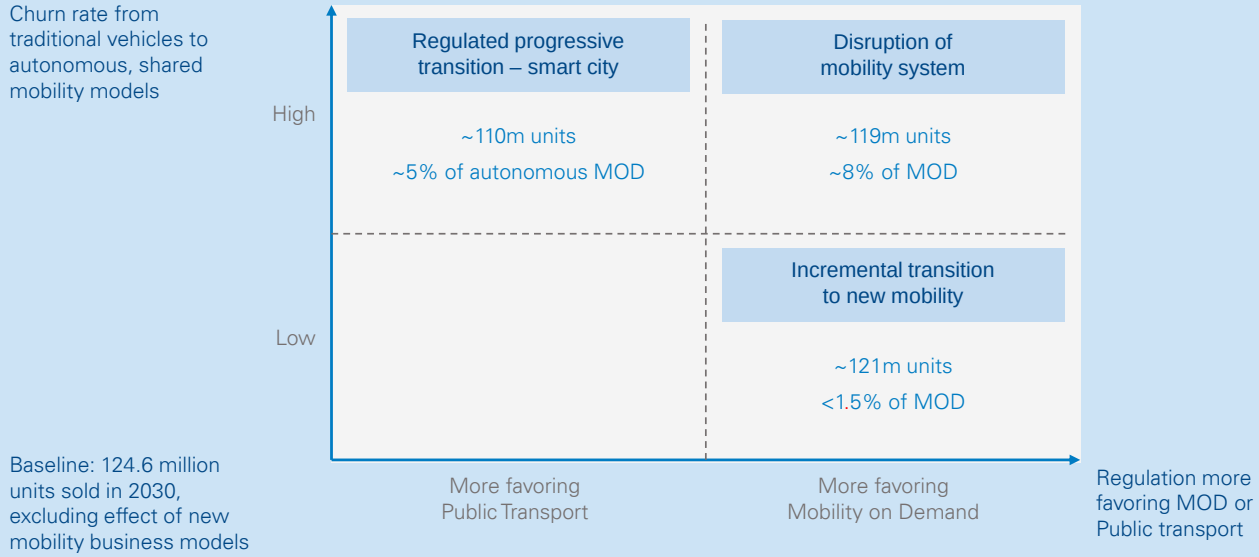
Nevertheless, the introduction of new mobility concepts will significantly change the make-up of the global car park: we expect that electrified vehicles (either full battery electric or hybrid) will have achieved a share of more than 50 percent by 2030 – depending on the segment. We expect the rise of mobility platforms offering mobility-on-demand through vehicles either produced specifically for this purpose or privately owned and temporarily put into the mobility system by the owner. It is frequently reported that the overall market size will significantly shrink over time. This is theoretically true; however, realistic scenarios calculated using real urban data and statistically relevant customer preferences currently suggest a total production volume worldwide of between 110 and 120 million vehicles in 2030, which is more than many experts predict. The advantages of the upcoming mobility options will lure customers from traditional modes of transport. Survey results conclude that, in an unregulated environment, almost one-third of those customers using public mobility modes such as trains and buses today could change their behavior and switch towards the mobility modes described above – adding further capacity requirements to the system.

We therefore expect, depending on the initial urban status of a city or region, that three key mobility scenarios will prevail:

- Regions which progressively move towards autonomous vehicles based on mobility on demand ("disruptors"),
- Legacy-constrained cities introducing new automotive mobility systems incrementally,
- Cities applying focused regulation to seamlessly integrate new automotive mobility modes into their public mobility systems, which they consequently extend (smart cities).

These changes will transform the "automotive pyramid". Extending the classic view of the automotive pyramid, three new segments with new roles will develop. Above the manufacturers who currently stand at the top of the food chain, the new role of "automotive mobility provider" (combining the functions of the customer mobility interface provider and operating system providers) will emerge.

Figure 8: Expected vehicle production by 2030



MOD: Mobility On Demand
Source: Arthur D. Little analysis

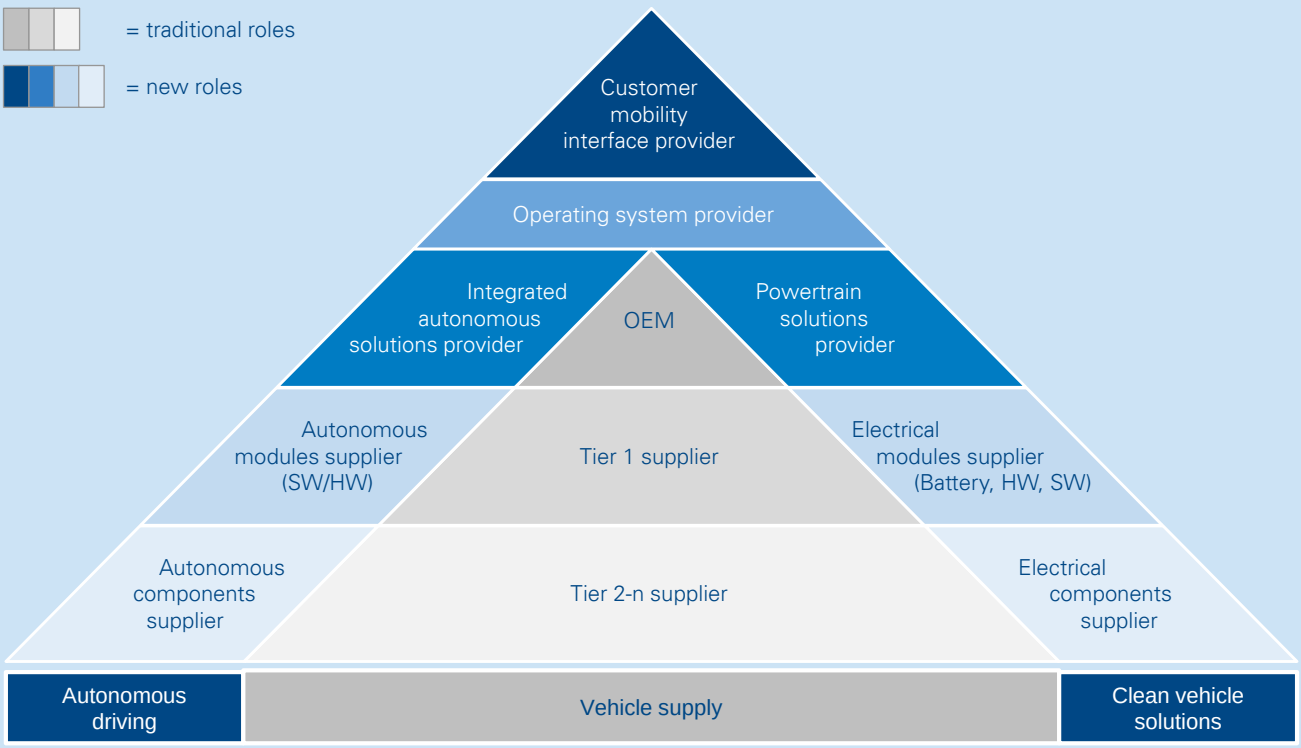
These players will offer mobility services to end customers, therefore capturing the customer interface. Along all levels ("tiers") of the automotive pyramid, new ecosystems for electrical and automotive modules and components are developing. Therefore, the pyramid of today (consisting of the key roles of manufacturer and supplier, tier levels) will be drastically extended – and this change will significantly affect the strategies employed by industry players.

For manufacturers, the new mobility system will require a significant shift in product portfolios – a change that needs to be managed. A polarization of vehicle segments can be expected, and the middle segments will shrink drastically. Furthermore, manufacturers will need to decide on their approaches and how to tackle the new evolving mobility provider segment – since due to the limited respective volume expected, exploitation of the respective profit pool will be challenging. Regional approaches to mobility models will also be required. Finally, the management of competencies and networks, as well as the integration of external sources of innovation, will be the key success drivers for OEMS on the road to building the right business model while maintaining a prudent approach to investment.

To master the new rules of the game, industry players now need to focus on seven distinct areas:

- Understand the new roles on the automotive pyramid, anticipate competitor moves within the new pyramid and define scenario-based, flexible strategy approaches,
- Prepare to manage a broader spectrum of business models,
- Secure access to the required technology and capability through systematic external innovation,
- Accelerate internal innovation capabilities for frequent and fast changes in innovation objectives,
- Adopt agile approaches to innovation,
- Capture market share on relevant electric-mobility products,
- Assess and secure the company's readiness for electric mobility

Figure 9: Future of Automotive "pyramid"



Source: Arthur D. Little, Future of Automotive Mobility

3. Where are we now?

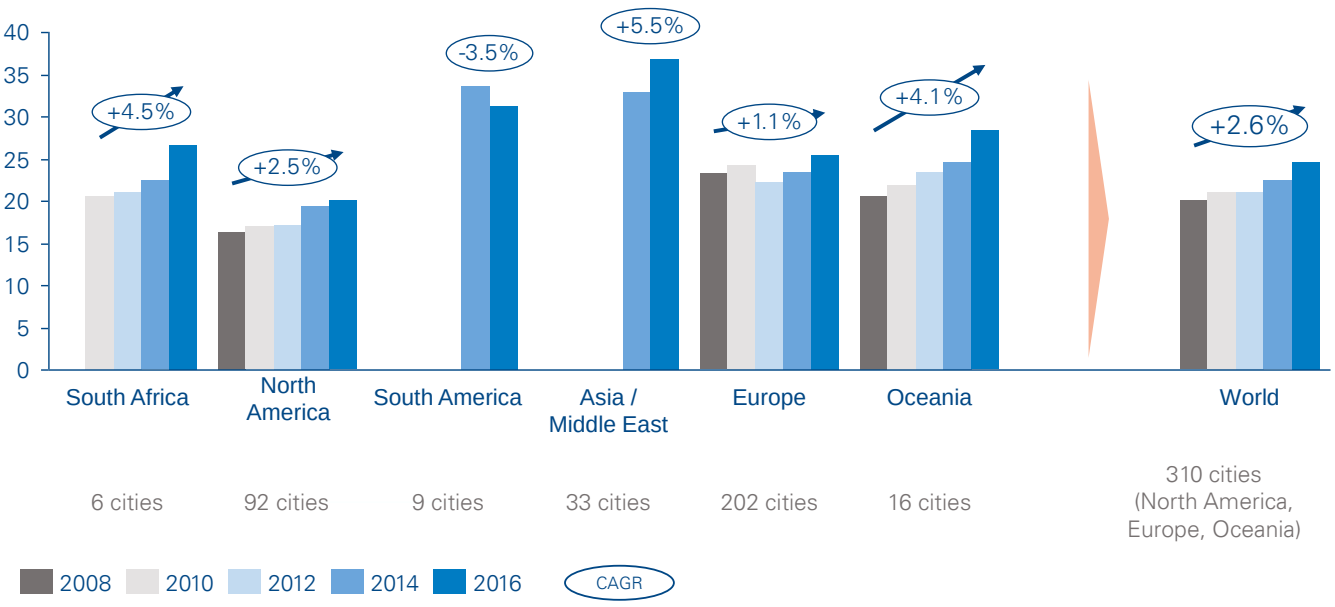
3.1. Back to the present – Need for an irreversible change of paradigm

There are clear indications of the need for an irreversible change of paradigm when it comes to urban mobility organization. In many urban areas, the quality and performances of mobility services are deteriorating. While this does not apply to each and every urban center, there is clear evidence in all megacities that we have reached a point at which steady improvement through incremental change will not be enough to cope with the challenges to come. Will conventional mobility management in urban areas be able to provide the required changes in quality and performance?

While the movement of people and goods is a prerequisite for economic development, non-movement – i.e., traffic congestion – constitutes the biggest pet peeve of households and businesses. The overall rate of road-traffic congestion is continuously increasing in urban areas across the world. (See Figure 10.)

When looking at the regional spread of congestion, we observe that the increase in congestion is more intensively driven by large cities (>800k inhabitants) and megacities (>10 million) than smaller cities. In fact, analyses of congestion in cities as a function of GDP per capita[18] show that from a certain level of GDP upwards, vehicle-kilometers and the total length of trunk

Figure 10: Evolution of congestion level per region [%, 2008–2016]



TomTom measures the congestion level (%) as the increase in overall travel times when compared to a free-flow situation

Source: TomTom traffic index 2016, Arthur D. Little analysis

roads grow at the same pace, leaving the ratio between the two – congestion – unchanged. This result recalls, on a global level, the classical work by Downs (1962, 2004) known as "fundamental law of peak-hour congestion". It states that, on urban commuting axes, after any new investment in capacity, roads will be as congested as before. In Europe, the long-term trend indicates that the existing high level of congestion continues to increase (see Figure 11) but at a slower pace than in the North America region, which comes from a lower base. It is likely that the average level of congestion in European cities has become so bad that people are unilaterally turning to alternative means of transport in order to improve their journey times. When it comes to the South American region, the reported congestion levels come with a health warning: the analyzed data set is of limited size: a dozen cities, mostly located in Brazil.

INRIX Research[19] showed that congestion across the UK, Germany and the US cost almost $450 billion in direct and indirect costs in 2016, or $971 per capita. The average cost per driver was $1,400 (US), £968 (UK), and €1,531 (Germany).

If the world fails to change its mobility habits and innovative mobility ecosystems fail to deliver on their promises, the future could be bleak. Estimates[20] suggest that by 2050 urban dwellers will spend, on average, twice as long in traffic jams as they do now, air and noise pollution will have increased massively, urban mobility systems will use five times more of the planet's bio capacities than in 1990, and overloaded transport infrastructures will present a major obstacle to economic growth.

3.2. Arthur D. Little Urban Mobility Index 3.0

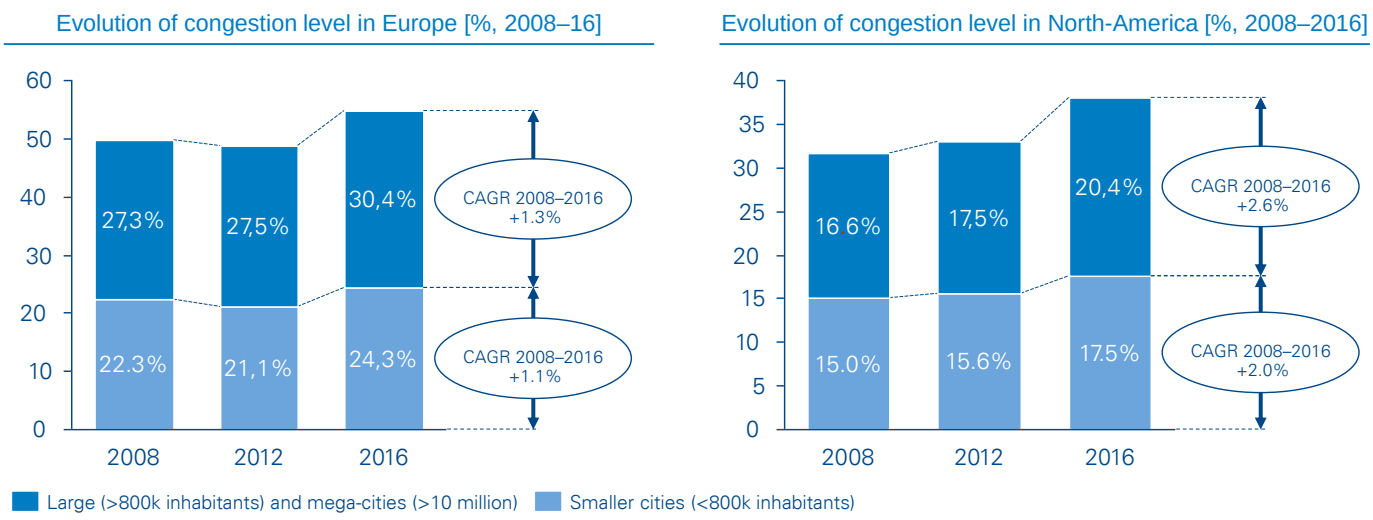
The third edition of Arthur D. Little Urban Mobility Index is released and available at the back of this report.

The new version of the index is more comprehensive than the 2.0 version published in 2014. Arthur D. Little's researchers worked on seven geographical areas across six continents, with 100 cities scrutinized – 16 more than for the last edition. The number of indicators surveyed has also increased. One hundred cities in the Urban Mobility Index 3.0 were assessed on the basis of 27 indicators split into three even groups – maturity, innovativeness and performance of mobility systems – measured by nine indicators in each.

The results of the Urban Mobility Index 3.0 show that the average score of the 100 cities surveyed was 42.3 out of a possible 100 points. This means that, worldwide, the average city has unleashed less than half of the potential of its urban mobility system, a state of affairs that could be remedied by applying best practices across all its operations. Cities need to work intensively on improvements to their mobility systems if they are to cope with the challenges ahead.

The highest score was achieved by the city-state of Singapore with 59.3 points, followed by Stockholm (57.1 points), Amsterdam (56.7 points), Copenhagen (54.6 points) and Hong Kong (54.2 points). This indicates that even the highest-ranking cities have considerable potential for improvement. Only 10 cities scored more than 50 points, out of which eight are European cities and two Asian.

Figure 11: Average congestion levels in Europe and North America



Source: Source: TomTom traffic index 2016, Arthur D. Little analysis

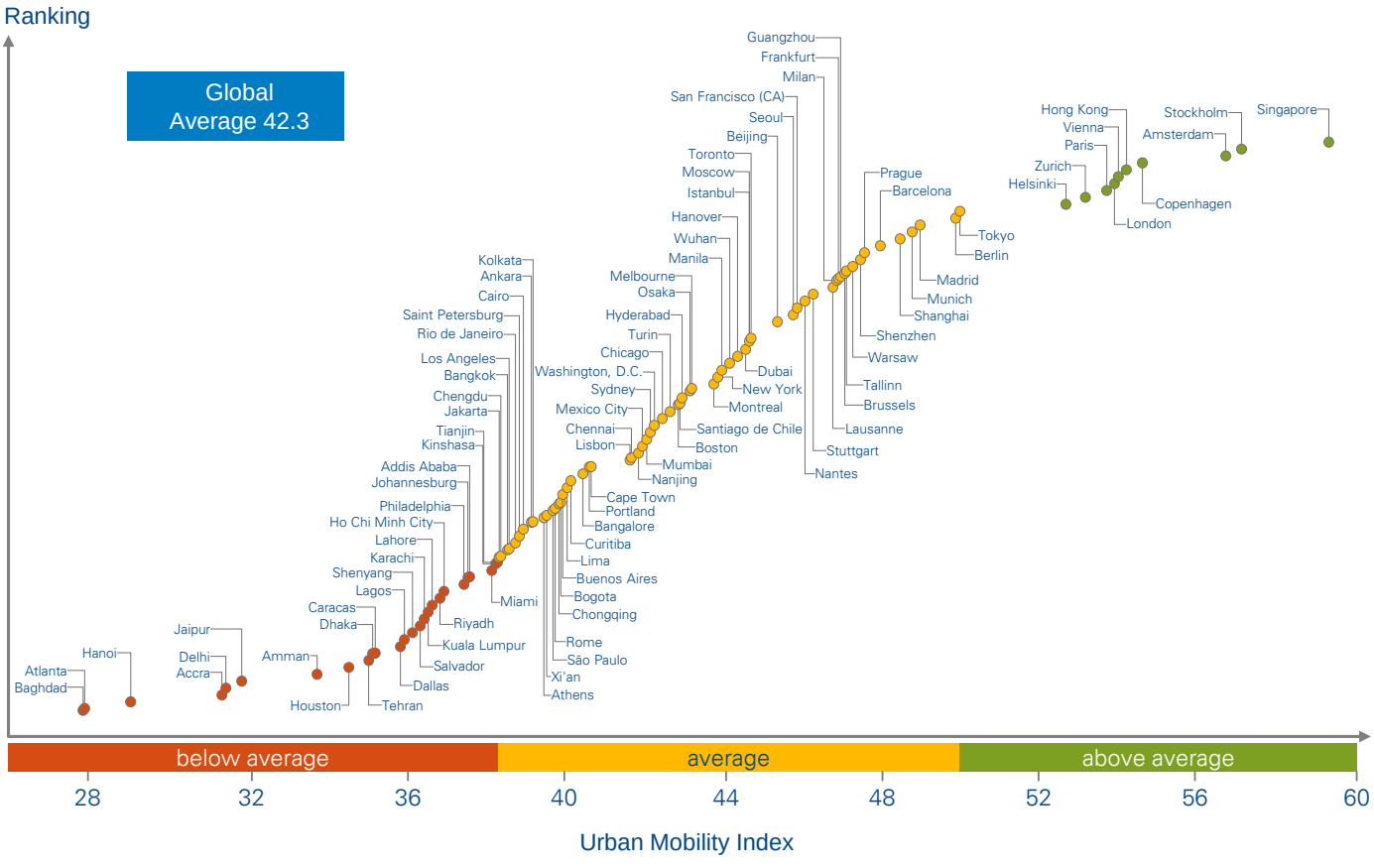
Twenty-six cities ranked below average, and these represent the lowest tertile of the final score data set. The vast majority of the cities with mobility systems that scored below average belong to developing countries in Africa and Asia. However, several US cities can also be found in this group, invariably because the private car makes up an unhealthy proportion of their modal split. These cities need to implement sustainable mobility models and decrease their dependence on cars.

Propping up the bottom of the index with a score of 27.9 points out of a possible 100 for its mobility system was the Iraqi capital, Baghdad.

Since the last index was published in 2013, some remarkable progress has been made in urban mobility. Having analyzed the data for the 84 cities that were included in both Urban Mobility Indexes 2.0 and 3.0, we can offer the following insight:

- The global share of motorized individual transport has decreased from 42 to 40 percent of the modal split, a welcome development. During the same time period, the share of public transport increased from 29 to 31 percent, while non-motorized transport remained stable at 29 percent.
- Average transport-related CO_2 emissions per capita decreased by 3 percent – from 1,506 to 1,464 tons.
- The density of cycling networks in the 84 cities increased by 26 percent – from 756 to 955 km per 1,000 km^2.
- The penetration rate of multimodal mobility cards increased by 27 percent – from 442 to 560 cards per 1,000 citizens.
- The penetration level of car sharing increased by 54 percent – from 116 to 179 shared cars per million citizens. At the same time, the penetration level of bike sharing increased by a factor of 10.7 – from 385 to 4,114 shared bikes per million citizens.
- The motorization level has increased by 5 percent, driven by dynamics in developing regions, from 380 to 398 cars per thousand citizens.

Figure 12: Arthur D. Little Urban Mobility Index 3.0 – City ranking



4. Which way forward – how to shape the future of mobility?

4.1. Opportunities to shape the mobility ecosystems of tomorrow

The conclusions from previous versions of the Future of Urban Mobility studies still hold true:

- Mobility visions and policies do not cover requirements. A lot of mature cities do not yet have clear visions of what their mobility systems should look like in the future and coherent strategies for getting there. Moreover, there is a lack of integration between transport modes, across different urban policies (environment, land planning, energy, social policy) and across regions, which has led to sub-optimal outcomes in terms of performance.
- The management of urban mobility still often operates in an environment that is too fragmented and hostile to innovation. Mobility systems often still do not respond sufficiently to evolving customer needs, combining single steps of the mobility value chain into an integrated system. Despite evolution over recent years, mobility systems still often do not sufficiently bring together key players to work jointly to foster lateral learning and develop innovative mobility solutions.

In order to address future mobility challenges, cities and mobility solutions providers must first adopt more comprehensive and well-coordinated management of mobility supply and move towards more proactive approaches to mobility demand management in order to better influence behaviors in space and time. The mobility systems of tomorrow should be intermodal, personalized, convenient, and connected, and encourage the usage of more sustainable modes of transport (public transport, cycling, walking) while integrating new mobility solutions and autonomous vehicles.

Convergence through digitalization constitutes a major opportunity to reinvent mobility systems as they gradually evolve to embrace "Mobility-as-a-Service".

Digitalization will be one of the main drivers for upgrading the mobility system to a completely new level – mobility will become "a truly connected system".

- Means of transportation that remain unlinked today must develop into "mobility ecosystems": customers will be able to get intuitive and continuous information about a comprehensive travel chain, get easy access to transportation (e.g., through mobility platforms), and enjoy easy and smooth methods of payment.
- The movement towards integrated traffic and network management will be accelerated, addressing the movements of both people and goods, due to the ability to interface systems across modes and the increased connectivity between people, vehicles and goods – which will boost the overall system performance in the process.
- Digitalization will enable new business models and allow new players to enter the mobility system as service providers. Today's traditional players may benefit, but some may be weakened if they do not proactively take part in the shaping of new mobility ecosystems.

Massive pressure on new players to enter the mobility market.

The traditional division of roles in the mobility sector is being challenged today, and could change dramatically in the future. As things stand, public transportation systems are mostly provided by publicly owned and financed providers, and the automotive industry is not perceived to be – and does not perceive itself to be – a true contributor to the system. The common approach is to sell vehicles to individuals. In a world where mobility evolves into a true system, the automotive industry and other service providers will be under pressure to make enormous efforts to be part of the new world:

- The automotive industry has shifted its attention to more comprehensive mobility service offerings. After experimenting with car-sharing offerings, various forms of fleet management, and add-on services to core mobility, we see more comprehensive concepts of new mobility services; automotive companies will position themselves as key service providers in integrated systems. They will offer new vehicle concepts – connecting their car fleets – and they will withdraw combustion engines from the market.

- At this point in time, all players in today's mobility value chain are discussing ways to broaden their services. Public transport operators, taxi companies and travel managers are all moving towards broader service portfolios. All of them want to escape what we call the "commodity trap" – the threat that pure transportation services will become more and more commoditized. Integrated and value-added services will gain much more importance.
- As mentioned earlier, the digital revolution allows new players to enter the market – and GAFA[21] and other giant tech companies also have to the chance to become key players on this transformed playing field.

Political systems are incrementally responding. Political decision makers all over the world, whether international, national or local, have developed agendas to support sustainable development, and the transport sector is one of the priority areas that is being addressed. The general target picture calls for reductions in both emissions and noise, as well as the sustainable use of materials (whether raw materials or manufactured goods). At all levels, legislation is being introduced to drive this change. On a global level we see numerous follow-up activities relating to the UN's Earth summit (Agenda 21), which have become an integral part of policy systems.

At national and local levels we see emission reduction targets and policies designed to change our mobility systems.

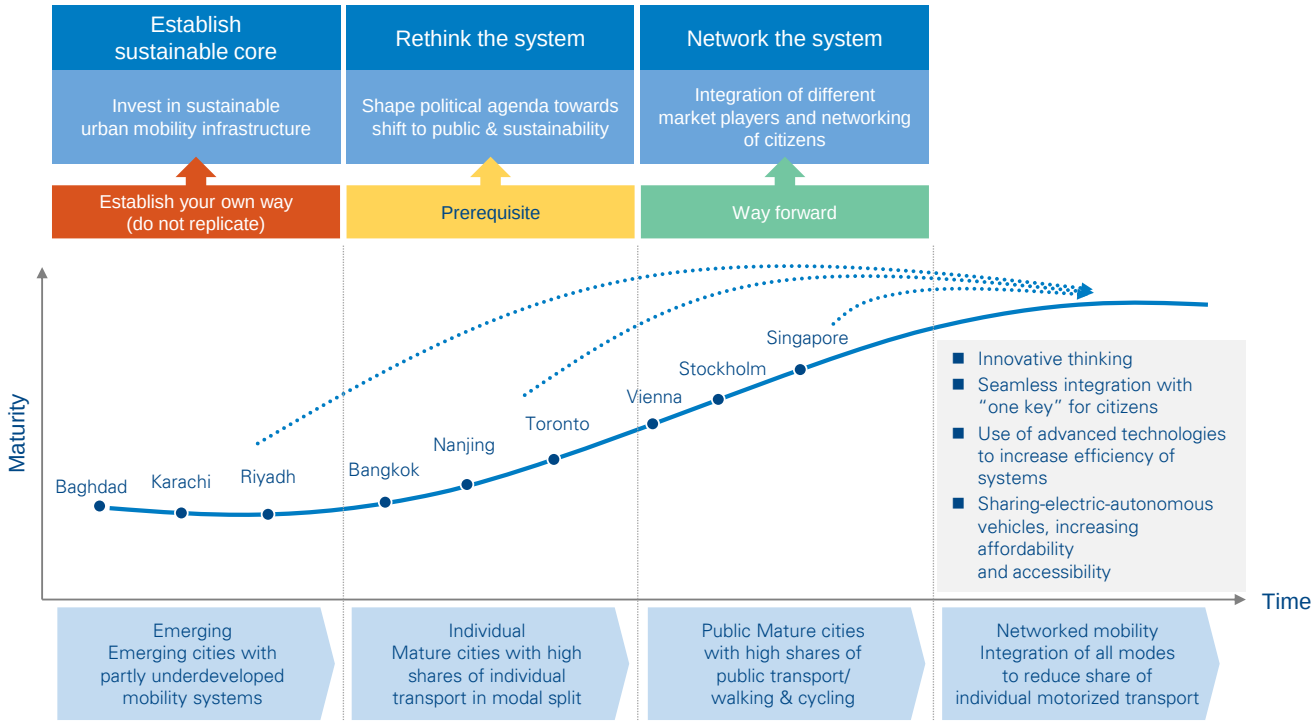
But how to make it happen? Different paths and different imperatives have to be considered by public authorities and (both traditional and new) mobility solutions providers as they strive towards sustainable and integrated mobility systems to serve smart and liveable cities.

4.2. Pathways to progress and strategic directions for transport authorities

Three pathways to progress for cities were revealed in prior Future of Mobility studies[22], each of them outlining specific opportunities and challenges that cities needed to address in order to make them fit for the future (see Figure 13):

- "Emerging" cities can invent their own sustainable mobility solutions. By capturing emerging transport infrastructure and technologies, they have the opportunity to become test beds for the urban mobility systems of tomorrow.
- "Individual mobility-oriented" cities, with high proportions of private vehicles, must rethink their systems towards more common and sustainable solutions.

Figure 13: Three strategic directions for cities



Source: Arthur D. Little & UITP, Future of Urban Mobility 2.0, 2014

- "Public" cities, with high proportions of public transport and where walking and cycling are practiced, must further network their mobility systems by fully integrating mobility solutions (for people, vehicles and goods) and interacting with their citizens to engineer changes in attitudes to sustainable mobility – and thus, a revolution in travel habits that benefits environmentally friendly options.

The solution for the future is an interconnected multimodal mobility system, with increased convenience and efficiency, tailored to the city's growth project and balancing economic development and well-being.

The second edition of Arthur D. Little's Future of Mobility study introduced four key strategic dimensions (see Figure 14) for transport authorities to focus on as they sought to develop sustainable mobility policie[23]:

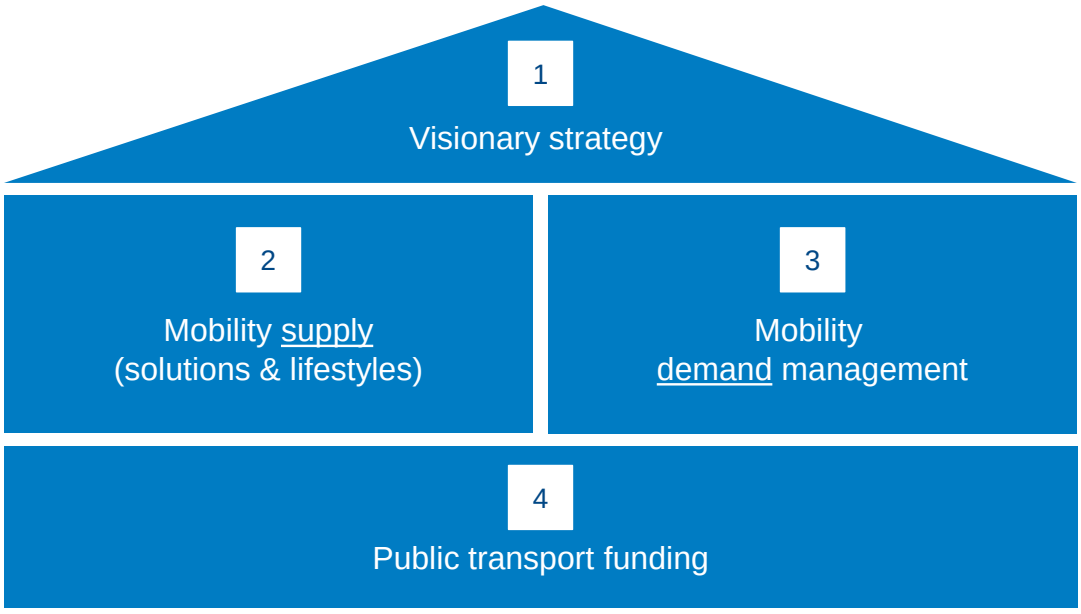
- A **visionary strategy**. Cities should develop political visions and decide on objectives based on the strategic alignment of all key public and private urban-mobility stakeholders. This alignment will ensure a balance between visionary ideas and project feasibility.
- **Mobility supply management**. Cities should extend their transport offerings for citizens, with a view to "delivering solutions" rather than "delivering transport". They should enter into partnerships and alliances with third parties, delivering user-friendly, multimodal solutions that meet everyone's needs.
- **Mobility demand management**. Cities should define ways (incentives/penalties) to encourage people to match their behavior to the mobility mode adopted. Measures do exist, some of which are tried and tested.
- **Public transport funding**. To ensure the financial viability of public transport and its operators, assessments must be made in three areas: opportunities to derive additional revenues from aggregation of third-party services; growth in passenger numbers; and revenue collection from indirect beneficiaries of public transport.

All four dimensions have to be carefully weighted by cities at the trial stage by factoring in the specific context of the country, and a strict implementation process must be followed, as the outcome will be influenced by the performance of the weakest link.

4.3. Strategic directions and imperatives for mobility solutions providers to consider

In this third edition of the Future of Urban Mobility study, produced in conjunction with our partner, the International Union of Public Transport, we take a closer look at the dimensions and strategic imperatives that need to be taken into account by

Figure 14: System-level framework for sustainable mobility



Source: Arthur D. Little & UITP, Future of Urban Mobility 2.0, 2014

mobility solutions providers when defining their visions and the strategies they will employ to differentiate themselves and drive attractiveness and competitiveness in this new era of disruption and creativity.

Five strategic directions to consider for mobility solutions providers

Evolution in the mobility ecosystem presents opportunities and challenges for both traditional and new mobility solutions providers. An increase in mobility demand, along with technological advancements and innovation, are providing new opportunities for operators. On the other hand, evolving customer expectations and changes in mobility behavior driven by societal mutation, as well as the entrance of new actors with differentiated business and operating models, constitute key challenges for operators, which are increasingly under pressure to deliver attractive solutions while ensuring financially sound operating models.

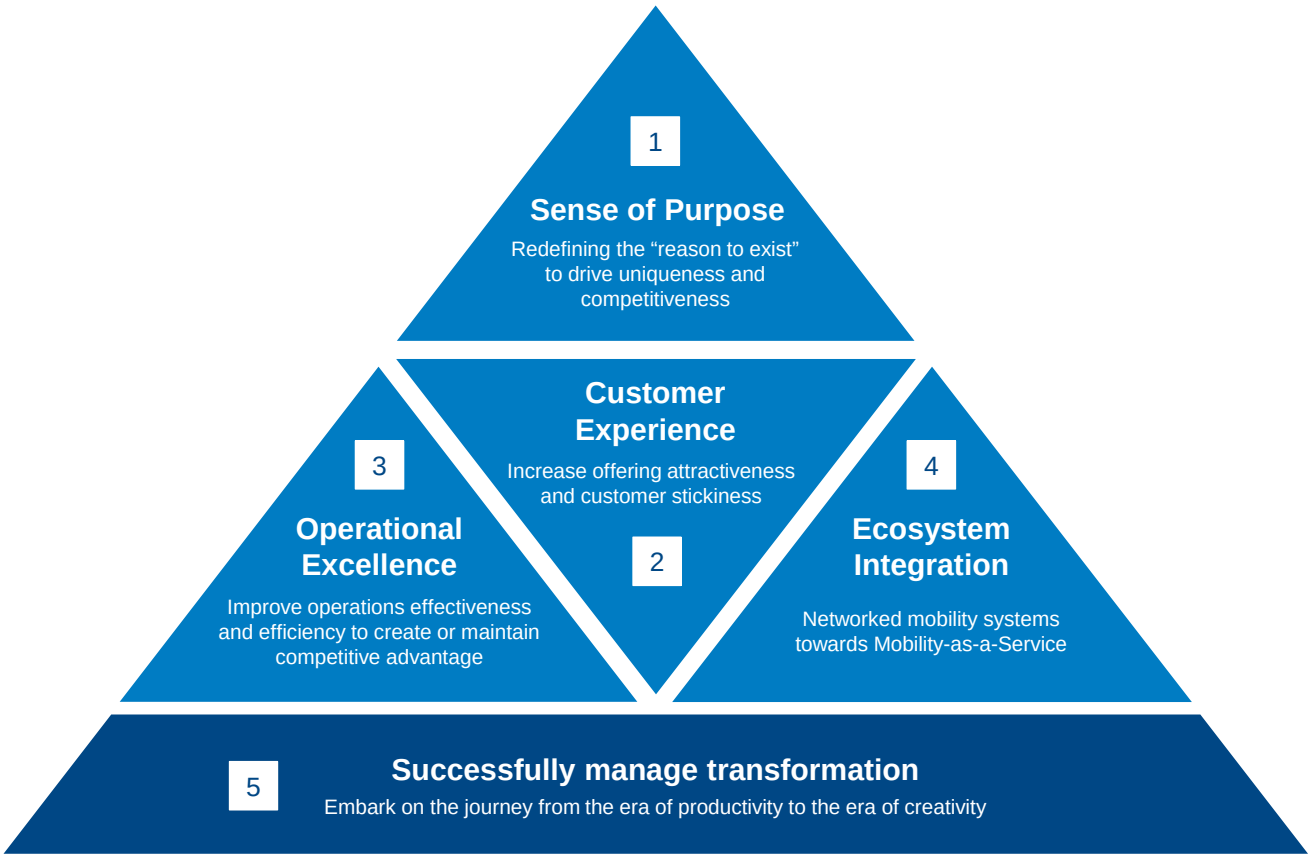
Arthur D. Little and the UITP have identified five key dimensions to be considered by mobility solution providers seeking to reinvent themselves in order to increase their offering attractiveness, drive (or sustain) competitive advantage and, ultimately, differentiate themselves within extended mobility ecosystems in the new era of disruption and creativity:

- **Sense of purpose:** Defining a sense of purpose (or "reason to exist") by reviewing mission statements, the brand platform and values, in order to secure differentiation in the marketplace. These changes should engage external and internal stakeholders alike: externally through emblematic proof along the customer journey; and internally by driving transformation at all levels of the organization.
- **Customer experience:** Increasing offering attractiveness and transforming customers into fans by better understanding mobility behaviors and customer needs, developing a superior customer experience across all touch points along the end-to-end journey, and developing a customer-centric commercial offering which takes into account differentiated customer needs.
- **Operational excellence:** Maximizing utilization of assets and improving effectiveness and efficiency of all functions across the value chain through effective long-term Capex planning, designing and operating future-proof transport and maintenance plans, and selectively implementing opportunities via innovation and digital technologies.
- **Ecosystem integration:** Providing consumers with flexible, efficient, integrated and user-oriented mobility services through developing integrated mobility visions and transport plans, increasing collaboration across mobility stakeholders, and implementing the concept of Mobility-as-a-Service to trigger a move from personal ownership towards usage of transportation solutions.
- **Successfully managing transformation:** In terms of leadership, culture, organization and talent management to remain competitive in the short term and relevant in the long term – a shift that involves a willingness to embark on a journey from the "era of productivity" to the "era of creativity".

Twelve strategic imperatives to be considered by mobility solutions providers when redefining their visions and strategies

Arthur D. Little and the UITP elaborate further on those dimensions and identify 12 imperatives for mobility solutions providers to consider when defining their sustainable visions and strategies, an overview of which is provided in the table below. Each imperative is described in more detail in Chapter 5 of this report.

Figure 15: Sustainable framework for mobility solutions providers to remain competitive in the short term and relevant in the long term



Source: Arthur D. Little & UITP, Future of Urban Mobility 2.0, 2014

Figure 16: Strategic imperatives to be considered by mobility solutions providers

Sense of purpose to drive uniqueness	#1: WHY definition	Defining a differentiating sense of purpose (or "reason to exist") to secure differentiation and engage external and internal stakeholders within a clear frame by reviewing mission statements, brand platform and value sets, moving from "product" and rational attributes towards "experiential" and "emotional" attributes
	#2: WHY activation	Activating the sense of purpose and brand attributes, externally through a set of emblematic proofs on key touch points across the customer journey, as well as internally by adapting processes, organization structure, governance and staff requirements to drive internal transformation at all levels of the organization
Customer experience to increase attractiveness	#3: Needs and behavior	Applying innovative need- and attitude-based segmentation approaches to better understand mobility behaviors and evolving customer needs as input for targeting the right customer segments, in order to develop a differentiated experience and design customer-centric commercial offerings
	#4: Superior experience	Designing a superior customer experience and developing a culture of service excellence by analyzing all company touch points (physical and digital) across the end-to-end customer journey, fixing the basic drivers of dissatisfaction while securing consistency and selectively creating "wow" effects to exceed expectations
	#5: Offering redesign	Developing customer-centric commercial offerings (offering architecture and solutions, products, services, pricing, distribution, CRM and loyalty program) to increase attractiveness – taking into account differentiated customer needs – build competitiveness and maximize commercial revenues and margins
Operational excellence to drive competitive advantage	#6: Long-term totex planning	Effectively capturing and planning long-term capex requirements based on a clear vision of what the network and operations will look like in 15 to 20 years' time, and setting up governance, incentives and control mechanisms to keep operating costs under control and optimally manage the backlog of capital projects
	#7: Operating model redesign	Designing and operating a future-proof transport plan and maintenance plan, allowing control of total cost of operations and maximizing fleet utilization and revenues through offering attractiveness and meeting operational requirements and institutional constraints such as public services obligations
	#8: Innovate for value	Understanding and continuously assessing relevance of innovation and digital technologies and developing a transformation roadmap to selectively grasp opportunities for increased effectiveness, efficiency and performance across the value chain, planning, infrastructure, operations, sales and support functions
Ecosystem integration towards Mobility-as-a-Service	#9: Integrate the system	Aligning with all mobility stakeholders on a long-term mobility vision and developing an integrated transport master plan at city or national level to reinforce inter-modality between physical mobility solutions and improve overall performance and attractiveness of mobility systems
	#10: Open the system	Defining an appropriate strategy to foster exchange of data and increase collaboration between public and private mobility stakeholders to foster the development of mobility solutions and services that are better aligned with mobility demand and further individualized, considering specific travelers' needs, habits and travel patterns
	#11: Network the system	Implementing the concept of Mobility-as-a-Service to provide travelers with a seamless and personalized door-to-door journey, maximizing customer experience and progressively triggering a move from personal ownership towards usage of transportation solutions-as-a-service
Transform	#12: WHY transformation	Successfully managing the company transformation in terms of leadership, culture, organization and talent management to remain competitive in the short term and relevant in the long term, implying a change of paradigm to embark on a journey from the "Era of Productivity" to the "Era of Creativity"

Source : Arthur D. Little & UITP Future of Mobility 3.0

5. Strategic directions for mobility solutions providers

5.1. Dimension 1: Sense of purpose – "Redefining the 'reason to exist' to drive uniqueness and competitiveness"

5.1.1. Introduction

Defining a sense of purpose, or "What is our company bringing to the world?", is becoming a necessity for companies as they face business environment challenges. It consists of:

- Defining the company's identity, as well as the original and differentiating understanding of its role.
- Making clear what the company brings to the world and what would be missing implicitly if it disappeared.

The concept of the "WHY" strategy was introduced many years ago, and it is often used in the definition of companies' mission statements. With rising business and HR-related challenges, defining the company's "WHY" is thus a major imperative to address:

- Disruption in the ecosystem: "WHY" creates permanence
- Commoditization: "WHY" helps in identifying or redefining new differentiation levers
- Evolution of customers' expectations and customer experience: "WHY" drives a customer-centric way of thinking
- New employees' relationships to work (with lower loyalty): "WHY" helps define "which cause do I serve?"

Within the mobility landscape, as the first players to open up in the 1990s, airlines are among the most advanced operators in terms of "WHY" strategy and provide examples of best practice when it comes to "WHY" design and activation. After the market opened up to competition, new players focused on cost reduction for short- and medium-haul, which badly damaged incumbents. These incumbents responded with differentiation in terms of services, in-flight experience, etc. Finally, low-cost companies are now working on differentiation as well, so competition is intensifying again. In the late 1990s, numerous rail and urban transport companies revisited their mission statements to fulfill political policy goals towards sustainable urban mobility, and nowadays most mobility solutions operators have identified their missions and sets of values.

As they are facing major challenges and disruptions (regulatory liberalization, increased intra- and inter-modal competition, etc.), mobility solutions providers are not exempt from the need to improve their "WHY" definitions and activations. It is both a challenge and a necessity to be true to their existing mission statements and value sets (and revisit them as needed), and to further activate their WHY through all levels of their organizations if they are to effect complex and deep transformations from the old economy to the "new era of creativity":

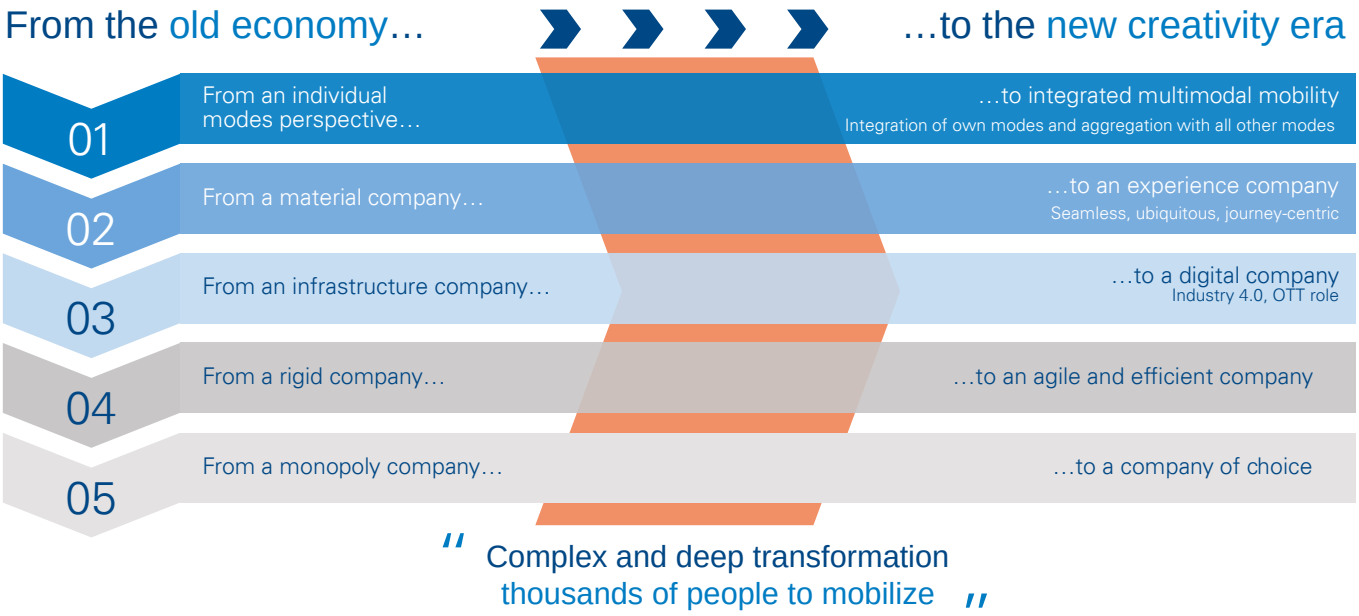
- From monopoly to deregulation with new competitors – with transport markets now progressively opening up to competition, traditional operators need to redefine their sense of purpose to differentiate, an imperative that has become more compelling, even in cities and nationally, where they retain near-monopolies.
- From an infrastructure and equipment culture towards a customer-centric culture, increasingly putting the customer at the center.
- In a digitalized world – where operators must rethink and secure the role of human capital.

Together these challenges are placing a huge strain on the ability of companies to strengthen, adapt and renew their brand images. However, in our research we found that many companies, although they recognize the challenges, have not yet grasped the importance of taking a fundamental look at their sense of purpose.

Defining a company's "WHY" or "sense of purpose" secures differentiation and common storytelling to stakeholders, as well as driving internal transformation. The sense of purpose is at the heart of a business, as it drives its uniqueness and competiveness:

- In a digitalized world, defining the "WHY strategy" makes companies' differentiation stronger and breaks up market commoditization and dilution.

Figure 17: Transformation from old economy to new era

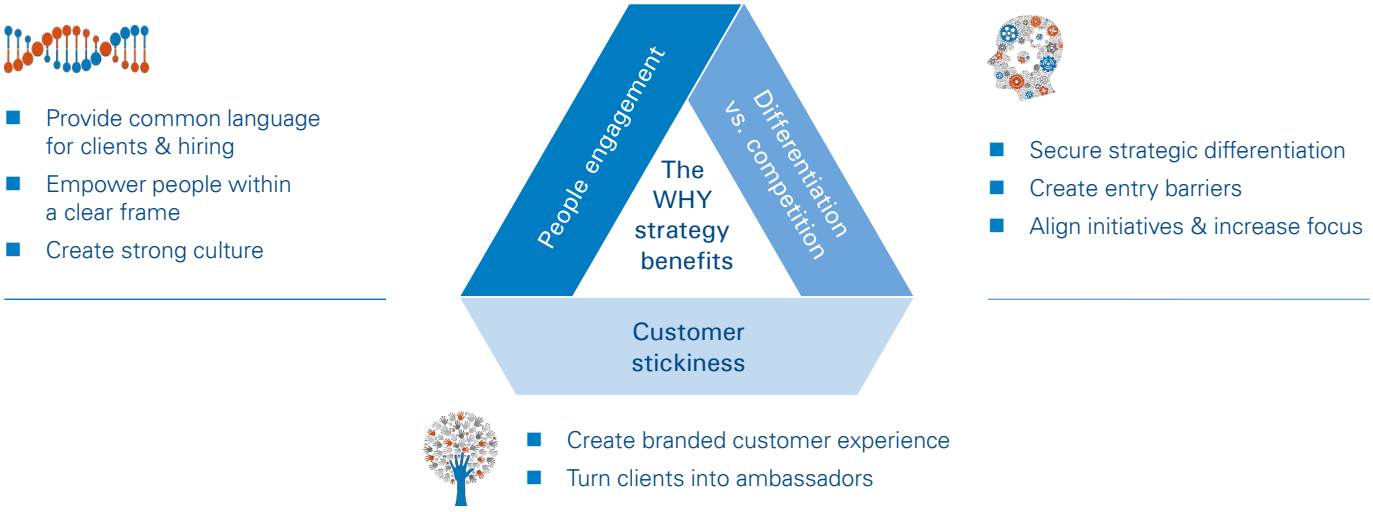


Source: Arthur D. Little

- In a fast-moving environment, companies need to define strategic purposes that are clear, long-lasting and resilient to strategic and environmental changes.
- Companies need to create customer stickiness and turn them into ambassadors.

In addition, as a new generation enters the labor market, employers need to rethink management. Giving meaning is a necessity if a company is looking to hire millennials, which makes the "WHY" both a necessity and an attractiveness lever[24]. The "WHY" strategy creates an "empowered" organization with a clear orientation, strong cultural cement and an effective filter through which all company actions must pass, providing – in the process – a common language for clients, hiring empowering people within a clear framework, and creating a strong culture.

Figure 18: The WHY strategy definition



Source: Arthur D. Little

5.1.2. Imperative #1: WHY definition

Defining the company "WHY" is about defining a unique purpose ("reason to exist") that allows to engage in a natural transformation, while reorienting the content of mission statements from "product and rational attributes" towards "experiential and emotional attributes".

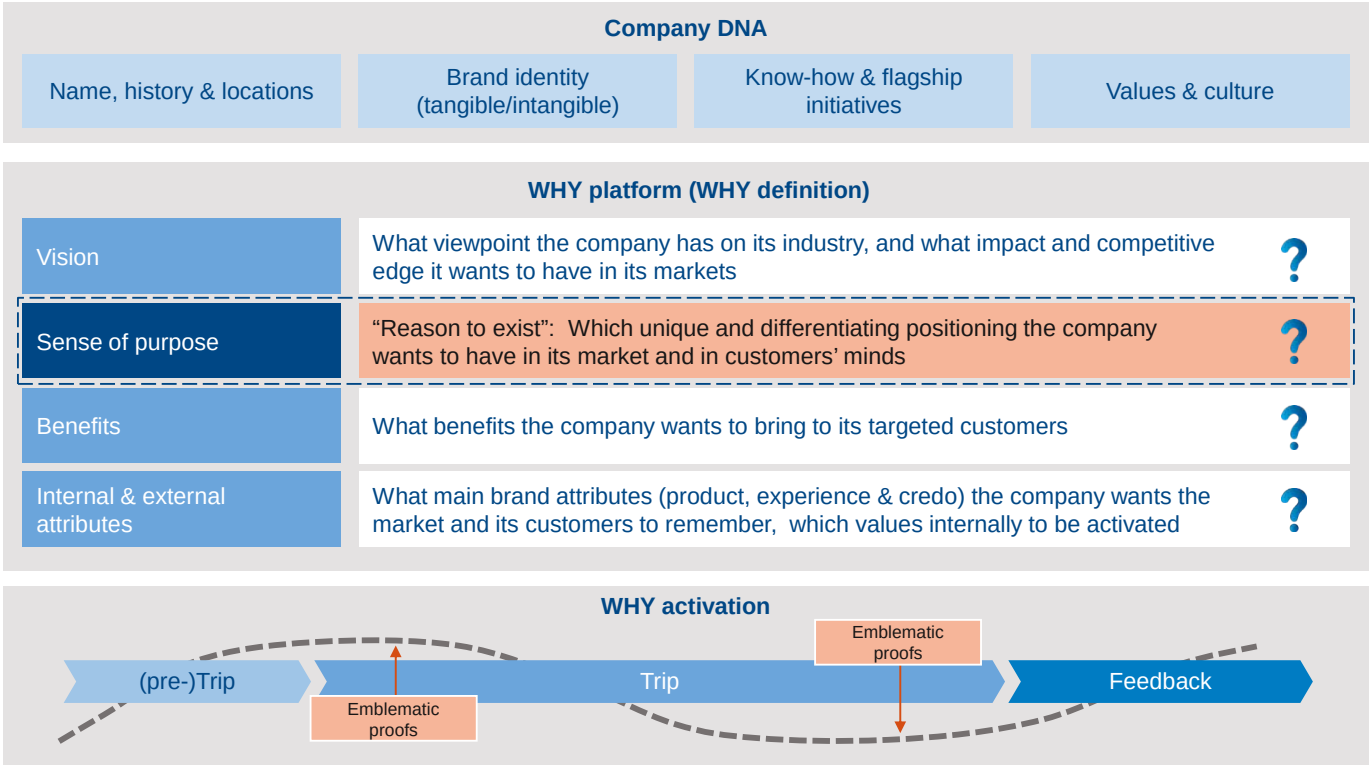
The definition of a "sense of purpose" can serve as a natural center of gravity for mobility solutions providers to secure and anchor their future paths to high performance. Definition of a clear "WHY" enables an **auto-generated transformation**, that:

- Filters and ensures coherence of all the company's activities and actions,
- Sets a unique direction for all ongoing and future projects,
- Engages and mobilizes employees towards a common "center of gravity" – the "Living" WHY,
- Offers a management tool that is enriched with proof-points and storytelling,
- Strengthens the WHY spread across the company.

The WHY platform, building on the company DNA, represents the core of the brand.

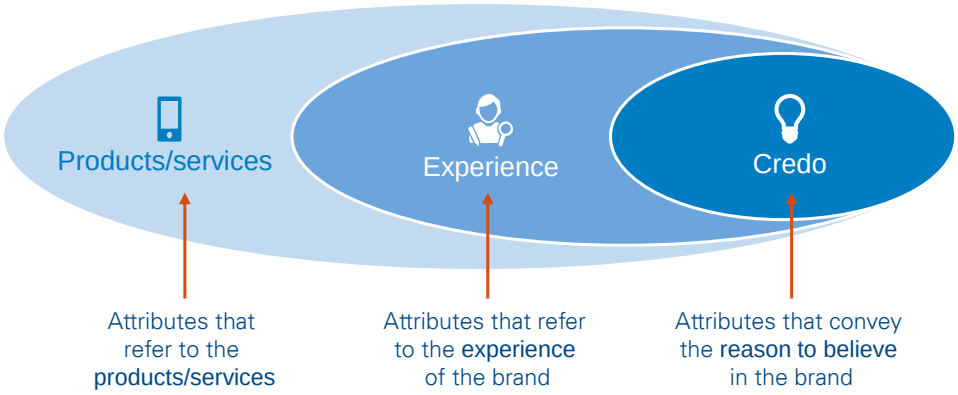
Attributes can then be activated internally and externally to drive a differentiated customer experience.

Figure 19: The WHY platform, building on the company DNA, represents the core of the brand



Source: Arthur D. Little

Figure 20: The "Why" or "Credo" is the heart (soul) of a firm … it drives its uniqueness and competiveness



Source: Arthur D. Little

When defining their brand attributes, most companies define them through their products – the concrete proof of the business the company is conducting. However, brand is meaning. The supremacy of strong brands lies in their reasons to exist, the fundamental philosophies they embrace, rather than the products they sell. Often this refers to a superior cause the brand legitimately embraces.

Modern thinking about branding emphasises the necessity of a comprehensive approach in which the various components of the brands are harmonious and managed. Only fully aligned and strong commercial and employer branding will contribute to success and differentiation. There is an absolute requirement to ensure that all functions are involved in the WHY definition, and not solely the marketing communications and HR functions[25].

5.1.3. Imperative #2: WHY activation

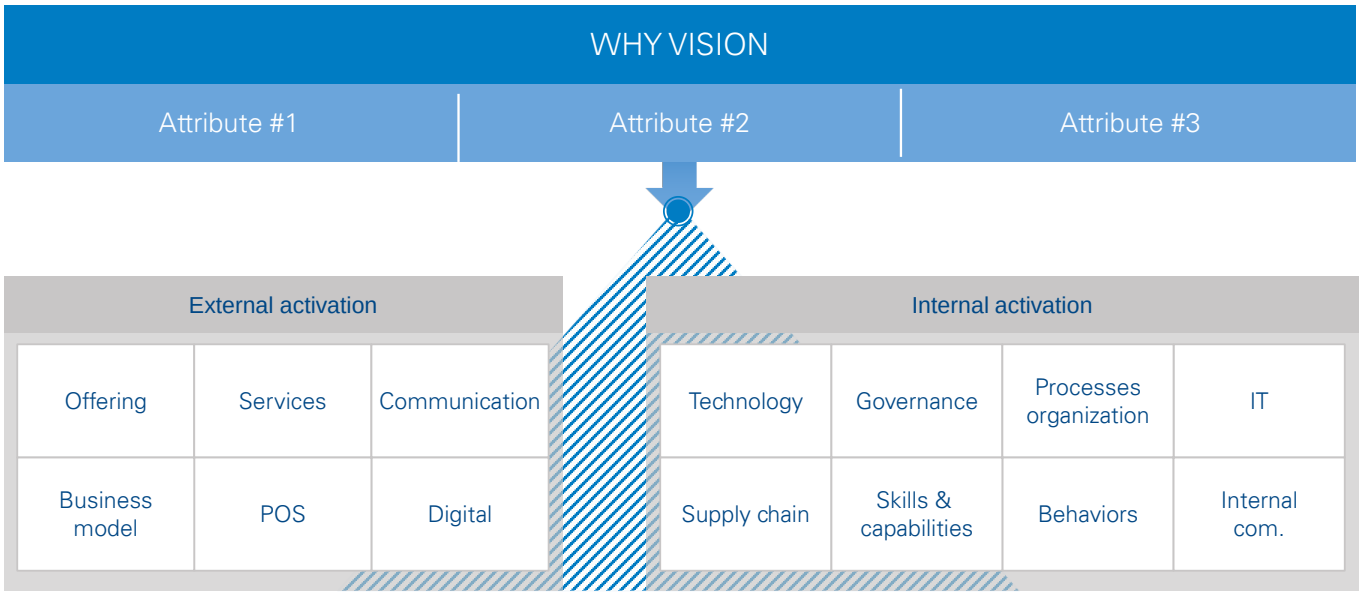
The key question relating to the effective implementation of a "WHY" strategy is: How are we to activate the brand platform ("sense of purpose" and brand attributes) both internally and externally?

For mobility solution providers, external activation of the brand platform will imply the redesign of touch points across the customer journey. This starts with the pre-trip elements – e.g., the way the brand communicates to its customers, perhaps via a mobile app to prepare the trip. Then the trip itself – e.g., development of new service signatures, and the tone of voice and personality of announcements on-board, at the station or at selling points. And finally, after the trip has been completed – e.g., how to collect feedback and deal with dissatisfaction. It may also imply the redesign of (part of) the commercial offering by translating brand attributes into differentiating value propositions or services and the customer-relations strategy (see imperative #5).

Internal WHY activation provides a "sense of purpose" for internal transformation. It will typically imply change requirements in terms of process (adaptation of roles and responsibilities for selected functions, adjusting hiring criteria and processes), organization structure and governance, and staff requirements (skills, capabilities and behaviors), in order to deliver the target "sense of purpose" and activate the attributes in a consistent and faultless way across the organization. WHY activation may also involve revisiting the existing set of company values and identifying the "attitudes" required of staff at all levels to ensure proper activation.

Alongside that, WHY activation has acquired such a level of significance today that it has taken on the function of a "vertical strategic backbone" for some companies. The WHY platform should act as an internal decision-making support tool to guide strategic choices at ExCom level, as well as a filter to select (on an ongoing basis) the most robust, consistent and emblematic proofs of the company brand experienced during the customer journey.

Figure 21: Internal and external activation of WHY platform



Source: Arthur D. Little

Case studies: WHY strategy definition and activation

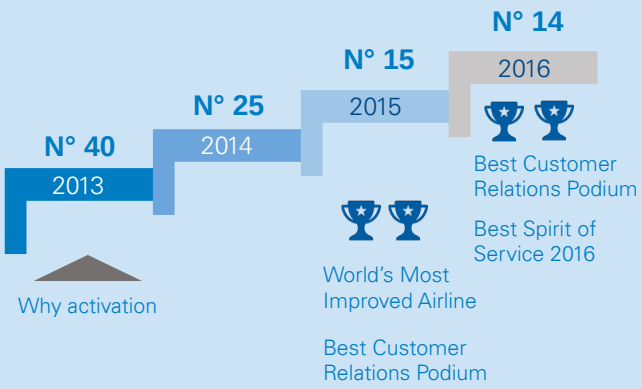
1) Air France – Redefined its "WHY" around differentiating attributes and redesigned its service, cascading its vision down to all customer touch points

Air France's aim was to reposition its brand away from the "distant" image conveyed over the last 15 years. With quality upgrade at the heart of its strategy, the company redefined its mission and credo beyond the product-focused function of shipping travelers from point A to point B. Instead, traveling must become a pleasurable experience marked by high-quality service, even a privilege.

Leaning on the French art of living, Air France redefined its attributes to offer an experience consistent with its "WHY":

- High quality (punctuality, exactitude, attention to detail, efficiency, safety, reliability).
- Caring attitude.
- Pleasure (pleasure to serve, choose, innovate, discover, share the best of France, where receiving is an art).

By redefining the brand's credo – traveling is not only going from point A to point B; it must be a privileged moment of pleasure and of high quality. Air France was able to differentiate in terms of experience, products and services, and this project resulted in successful activation through multi-support deployment.



N° x Skytrax ranking of Top 100 airlines

Source: Air France annual reports 2016, 2015 and 2014

Air France's main brand attributes have been applied to different levels of the experience. These include the new service signatures for a caring attitude, elegant interior design, a new safety demonstration video with codes of French elegance, on-board gastronomy based on French terroir and traditional dishes or renowned chefs, a travel kit redesigned to the new graphic charter, a fashionable and elegant clutch bag, etc. After introducing its new approach, Air France enhanced its international ranking as best carrier and received several customer-relations prizes.

2) Arriva group – Development of a set of shared values to give meaning to employees across the world

Arriva group successfully created and activated an employer brand across all its networks operating in different countries and regions, across all its various types of jobs, and among all its 55,000 employees. The innovation of its employer brand strategy and policy was to apply it not only at the recruitment stage, but also during employment and even after.

Together we are Arriva

At Arriva, you have over 60,000 colleagues, working in many cities, towns and regions. Between us, we do all kinds of jobs, in a variety of settings. Wherever you got at Arriva – and whoever you talk to – you'll see we take pride in our work. We all want to do well, and are keen to help each other. Every Arriva employee is part of a global team of people.

Together we provide a range of high quality, good value transport seervices, based on finding new ways to improve our customers' journeys while reducing the impact of transport on the environment.

Belonging together

Arriva is local and global We're part of the communities we serve, and part of a global group. We welcome people from different backgrounds with diverse skills and talents. If you're good, you're welcome.

Caring together

People are proud to work for Arriva. We care about each other, our customers and the wider environment. Your wellbeing is important to you and it is to us. We all work together to make Arriva a great place to work.

Talking together

Your opinion matters and your ideas can really make a difference. We encourage open discussion and will keep you up to date on what's important to you in your job.

Growing together

We want you to love your career and to grow as our business grows. You'll have the opportunity to learn and develop, while working as part of a successful team.

Rewarded together

We value your contribution and we recognise a job well done. We provide a range of benefits across our group, reflecting the wide range of skills and expertise of our people.

▶ The innovative and successfull Arriva brand strategy and policy

Source: Arriva

Approach to consider to define and activate WHY strategy

A straightforward approach can enable companies to (re) define their sense of purpose and brand attributes to drive an impactful transformation.

The first challenge is to gain an in-depth understanding of the company assets, an inheritance on which one can build, from its values and culture to its expertise and flagship projects. Next, it is important to examine which issues need to be addressed in the face of both internal and external challenges. The company positioning might need to be reshaped to take account of a changing world. Meanwhile, with the ecosystem in which the brand operates being shaken up by agile competitors, disruptive market entrants and evolving customer expectations, it is key to put in place an appropriate strategy to address these challenges.

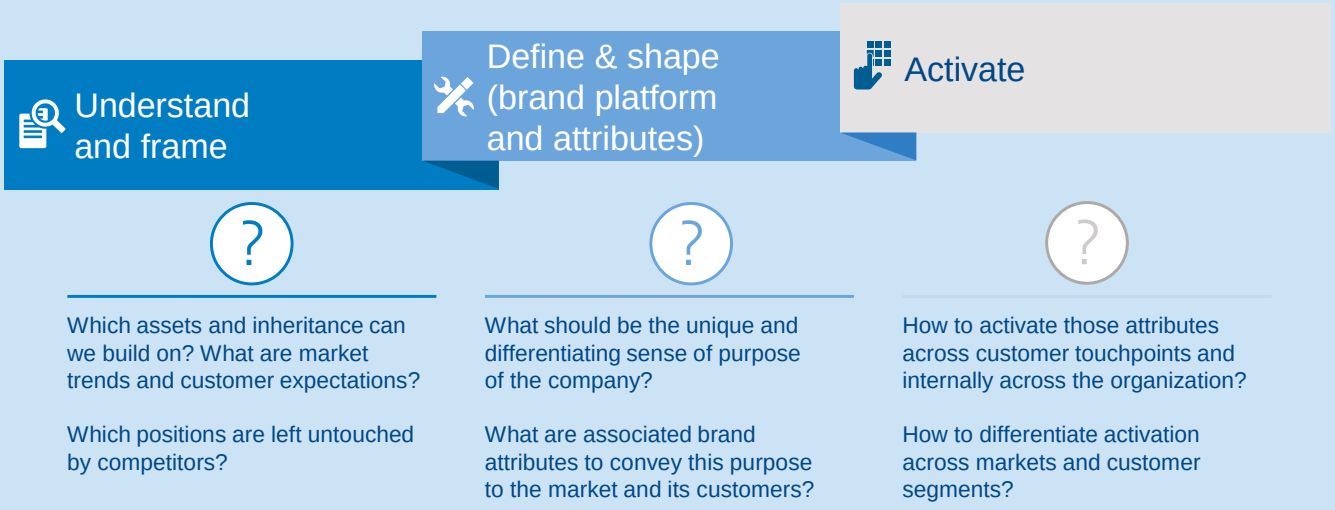
Having identified the task ahead, the next step is to lay the foundations of a brand platform based on reviewing the mission statements and value sets through the definition of the brand vision and a unique and differentiating sense of purpose for the company. ("What does the company bring to the world?") The new approach must embrace tangible brand attributes such as products and services, as well as intangible ones such as customer experience and credo.

The groundwork complete, activation becomes the priority. The new strategy needs to be delivered across all customer touch points and, if new groups of customers are identified via a differentiated segmentation strategy, a targeting and positioning process will have to be gone through. Such changes will inevitably have an impact on the company's leadership, culture and processes. All these aspects of the business must be geared to developing a master plan, which will allocate responsibilities and resources, and a budget that is synchronized with funding streams.

Lessons learned from WHY strategy projects:

- Engage top management in defining the WHY from the beginning of the project in order to not disconnect WHY selection from business challenges.
- Do not assume the WHY is predefined; well-defined WHY strategies often deviate from existing mission statements, in terms of both definition and activation.
- Do not consider the WHY only a marketing or communication approach.
- Make a choice: Activating a WHY strategy is not only about adding emphasis to the WHY, but also about arbitrage and renunciations (i.e., stopping current initiatives/projects).
- Listen to the base (people involved in daily delivery of operations) and engage with them to ensure meaningful WHY activation planning and execution.
- Do not execute the project independently of ongoing projects.
- Give the same importance to both the project process & approach and its content.

Figure 22: WHY strategy approach



Source: Arthur D. Little

5.2. Dimension 2: Customer experience – Increase offering attractiveness and customer stickiness

5.2.1. Introduction

Customers expect experience and meaning – an ability to understand and activate these offerings is key to securing stickiness and turning clients into fans. Societal and market evolution is putting mobility solutions providers under ever greater pressure, requiring them to further differentiate their products to maintain and strengthen competitive advantage:

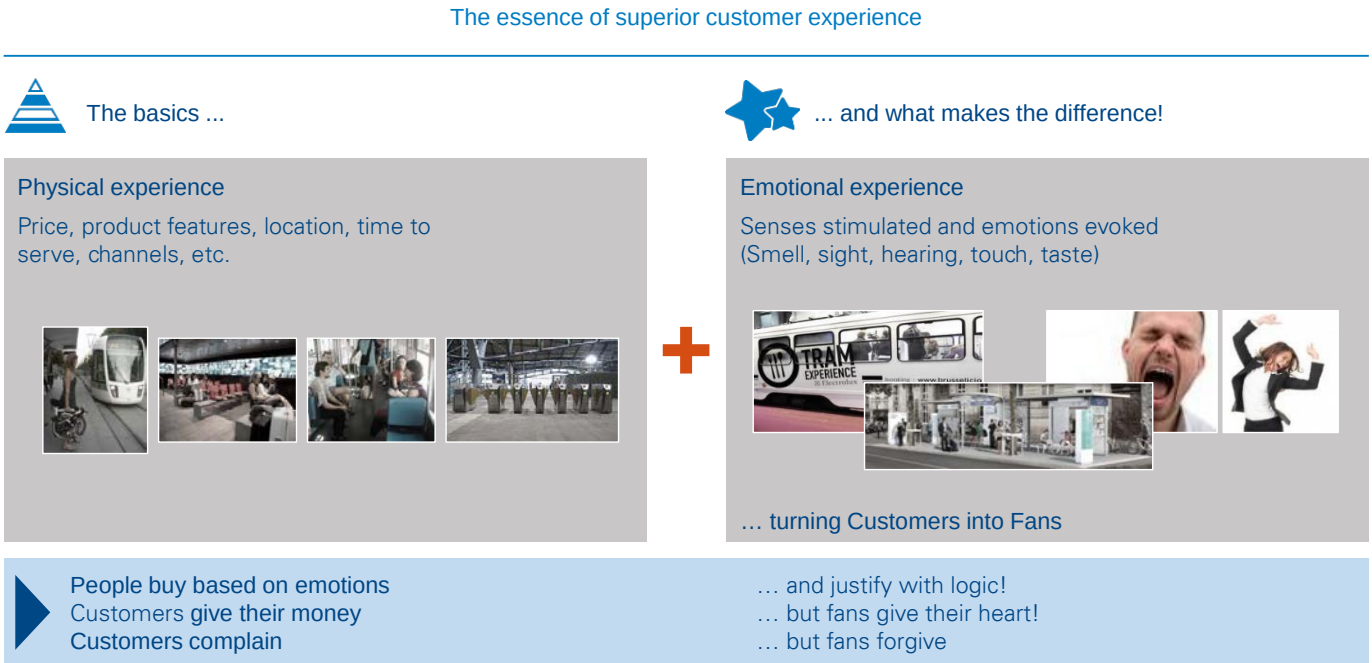
- The mobility market has been impacted by technological and regulatory changes, which increase traditional and inter-modal competition and lead to the emergence of disrupting new players.
- Customer behaviors and expectations are changing, and operators need to respond by offering more personalization and fluidity.
- Customers are expecting more than a product and a service: they want experience and meaning.

Customer experience is "the customer's engagement with an organization across all touch points of their end to end journey". This will include the core transport service – in many cases getting them from A to B reliably and safely – and other interactions they experience as part of their journey, e.g., customer information, staff, the built environment, cleanliness, ease of buying a ticket, accessibility and levels of crowding[26]. However, customer experience goes beyond these basic hygiene factors. It also includes the interactions customers have with companies while not traveling, such as the public transport operator's website, its customer-contact center, apps, social media, refund procedures, direct mail, consultations, advertising campaigns and safety initiatives.

Building a superior customer experience is key to differentiating and succeeding. Firstly, a better understanding of customers' habits through innovative marketing segmentation approaches (e.g., attitude-based) can serve as the basis for a redesign of the customer-centric commercial offering. Secondly, the design of a superior customer experience must derive from an analysis of the company touch points throughout the whole customer journey. Customer experience initiatives should focus not only on "fixing the basics", but also on securing consistency and creating "wow factors" that exceed expectations.

Developing a superior customer experience also calls for a focus on the staff experience. If employees are fans, they will

Figure 23: Customer experience is all about turning customers into fans



Source: Arthur D. Little

be advocates for the business and its products and services, and will go the extra mile to produce service excellence for the customers. Only employees as fans can deliver an emotional experience.

Finally, yet importantly, improving customer excellence will also require a revision of the overall commercial offering, through a comprehensive review of all its key components – transport plan, products and services, pricing, distribution, customer-relationship management and loyalty programs – to increase the overall offering attractiveness and thus foster customer loyalty.

5.2.2. Imperative #3: Understand needs and behaviors

In a fast-changing environment, it is vital that mobility solutions providers develop understanding of the evolution of customers' needs and expectations. (See figure 24.)

Societal evolutions have deeply shaken the traditional customer segmentations, and consequently the way offers are structured. Customer segmentations, as defined by transport companies, are most often based on socio-demographic considerations (e.g., age group and leisure versus business), and typically limited to their existing customer bases.

Socio-demographic segmentation tends to be outdated due to societal evolutions and changes in customer behavior. More insightful customer segments and an improvement in the understanding of inter-modal competition can be gained by developing attitude-based segmentation. Beyond socio-demographic drivers, mobility segmentation should be behavior- and attitude-based, and cover mobility as a whole.

Moreover, attitude-based segmentation can serve as a valuable tool in the redesign of the customer journey and commercial offering. Mobility segmentation must support strategic thinking on the evolution of the commercial offering:

- Companies should share a common vision of their customer segments in order to better identify and prioritize the strategy to be deployed when it comes to customer experience optimization.
- Segmentation should serve as the basis for the identification of the most critical segments and aid the definition of appropriate actions to increase the offering attractiveness to target segments.

A recent Arthur D. Little segmentation project achieved very insightful results using attitude-based segmentation. Our

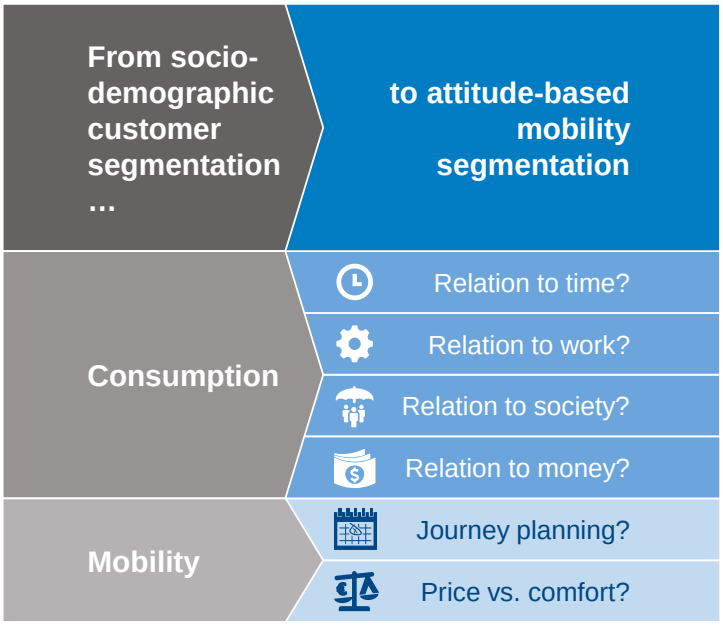
Figure 24: Triggers for transport operators to better understand customer needs

Trend	Situation	Implications
Evolution of customers' expectations and behaviors	■ Important societal, technological and behavioral **mutations** … ■ … mean the emergence of **new expectations,** but also complicate behaviors and the capacity to understand them	Understand and anticipate the evolution of customers' expectations to develop consistent products and services
Emergence of new players and disruption on value chain	■ Development and democratization of **new mobility offers** (car-sharing, autonomous car, bicycles, self-service scooters, etc.) ■ Development of **multi-modal platforms** enabling easier arbitration between price/duration	Reinforce competitive position of public transport and interface it with other transportation solutions
Gradual market opening to competition	■ Public transport operations are **gradually opening to competition** ■ **Competition** from other operators for the granting of new markets is increasing internationally	Demonstrate to authorities the ability to understand customers' needs, in order to maintain existing concessions and gain new ones

Source: Arthur D. Little

quantitative study demonstrated, for instance, that railway penetration of long-distance journeys was driven by behavioral factors (e.g., relation to time, consuming mode, digital penetration) rather than socio-demographic elements (e.g., socio-professional category, age, address). Attitude-based segmentation of the urban mobility market in a western European region also allowed us to identify interesting findings in terms of the differentiated needs that drove the evolution of the commercial offering, as well as its sensitivity to price. These findings allowed us to initiate strategic thinking on how to improve the offering attractiveness for target segments (customers and non-customers), as well as identify the key levers that could improve commercial performance.

Figure 25: Behavioral and attitudinal segmentation to cover mobility as a whole



Source: Arthur D. Little

5.2.3. Imperative #4: Build superior customer experience

Building superior customer experience is of critical importance for mobility solutions providers as it allows them to progressively turn customers into fans, thereby promoting long-lasting relationships.

Building superior customer experience is a full corporate program. The underlying levers that enable a company to deliver an unmatched differentiated experience are very fundamental in nature:

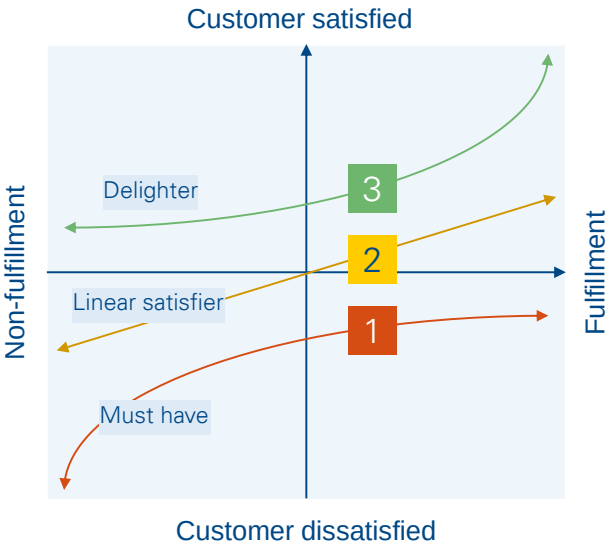
- A clear "WHY" vision that is conveyed at each step of the customer journey.
- A universal embracing of brand values (the "WHY") that means staff deliver a "branded customer experience" to the customer at each step of the journey.
- A multi-channel approach (including both physical and digital channels) to deliver a personalized experience to customers across all channels.
- An approach driven by insight into and understanding of customer behaviors, not by pre-conceptions: listen and really understand!
- A solid embedding of these values within the organization, as a corporate transformation enabler.
- A review of governance, means and resources, and their translation into the organization, processes, HR, internal culture and management approaches, e.g., defining the right KPIs to monitor change (more agile and immediate KPIs, etc.).

While customer experience programs should focus on "fixing the basics", they should also secure overall consistency and create "wow effects" to exceed expectations. Mobility solutions operators that have excelled in building superior customer experience have delivered such programs by employing three key levers:

- Fixing the basics – Improve "must haves" and eliminate major drivers of customer dissatisfaction by ensuring the provision of services meets industry standards along the customer journey.
- Creating satisfaction – Ensure a consistent approach towards passengers throughout the journey that is in alignment with the company's brand attributes (see imperative #1) across all touch points – "It only works when it all works".
- Introducing delighters – Exceed passenger expectations at selected touch points to create moments of truth and a "wow effect" that builds emotional attachment – a customer who has been transformed into a fan via wow factors will tend to forgive more basic shortcomings.

Enhancing service-offering quality and improving customer experience, while simultaneously getting costs under control, requires mobility solutions providers to prioritize their actions and make the required trade-offs according to their expected impact. Customer experience improvement typically follows a structured

Figure 26: Components of customer experience improvement plans



1

Must have – "Fix the basics" to eliminate drivers of dissatisfaction

Drivers that produce strong reduction in customer experience if they are not fulfilled, but have limited impact when fulfillment goes above requirements

2

Linear satisfier – "Ensure consistent approach in line with brand attributes":

Customer experience decreases or increases proportionally with the fulfillment of these initiatives

3

Delighter – Create WOW effects by exceeding customer expectations at selected touchpoints ("moments of truth")

Initiatives that do not reduce customer satisfaction if not fulfilled, but have strong impact when fulfilled

Source: Arthur D. Little

approach that begins with an understanding of performance and needs, and ends with implementation of the required actions:

- Mapping all touch points across the customer journey and exploiting existing and new ideas to maximize the experience.
- Prioritizing of "focus areas" and ensuring that they align with company strategy, customer needs and brand attributes, and are in balance with other improvement levers.
- Monitoring of consistency and end-to-end experience across touch points and channels – all touch points need to be aligned in delivery with consistent emblematic proofs.

Customer excellence is not only the concern of every department, but also of every individual within the organization, as any initiative can impact it positively or negatively. Superior customer excellence is achieved through the implementation of a combination of different levers. (See figure 27.)

Modifications that will enhance the customer experience on both urban and long-distance transport will typically include improvements to the core transport offering to reduce dissatisfaction and the introduction of value-added services – thus strengthening customer loyalty. Many of these innovations will be made possible through the rapid advancement of technology and, particularly, the digital revolution.

Within each of those areas, the key to success is the ability to select the right combination of levers, while keeping costs under control. The most effective levers for enhancing customer experience do not always need to be the most expensive. Alongside hard measures (mostly infrastructure-related and involving high capital expenditure) and measures related to the introduction of new technologies, the role of management measures (e.g., adapting processes to promote increased customer-centricity) and soft measures (e.g., training to improve field communication) should not be underestimated. Ultimately, decisions to exaggerate or renounce specific customer-excellence initiatives should be driven by customer needs (of selected target segments – see imperative #3) and in line with company attributes, which are themselves aligned with the company's sense of purpose. (See imperative #1.)

The development of a superior customer experience also demands a rigorous focus on the staff experience[27]. Building a culture of service excellence in order to respond to the increasing and ever-changing needs and expectations of

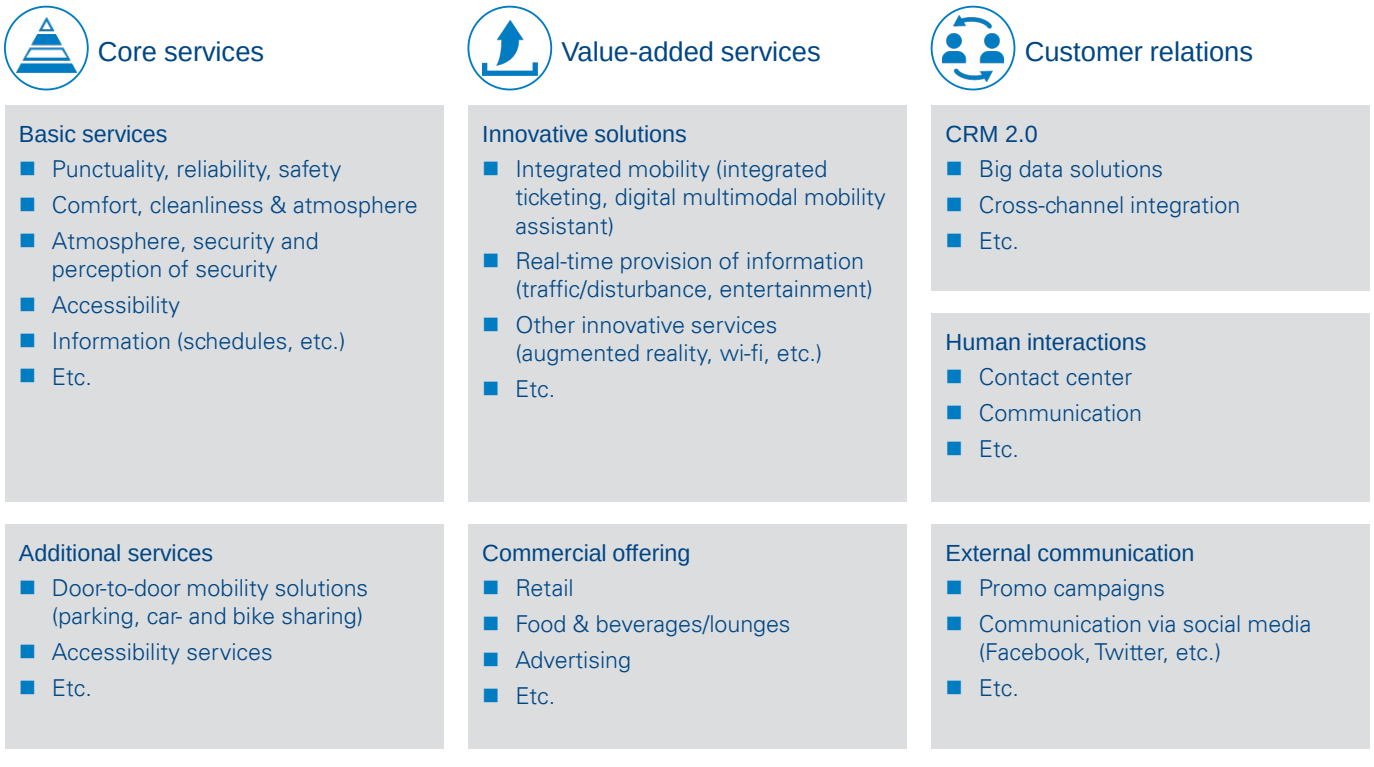
customers is critical if mobility solution providers are to deliver a positive experience to customers. Moreover, the benefits are manifold as building a culture of service excellence significantly contributes to increased performance, improved productivity, and stabilized or decreased absenteeism.

Beyond words and expressions, service excellence is a broad concept that covers the quality of core services, the quality of service delivery and, by implication, the quality of staff relations. If the quality of service is key to customer satisfaction, then how employees interact with customers is key to the quality of service.

Driving people's excellence implies changing the business culture by making the human factor a central concern inside the company: in its structure, organization, communication and management. It primarily consists of restoring to each staff member the responsibility of his/her job, respecting the principle of service symmetry (customer satisfaction = employee satisfaction), and investing as much in employee experience as in customer experience.

This approach also has important implications for internal communication, with the development of a common language and a new way of seeing things, the empowering of people to find solutions, and the creation of a virtuous cycle of continuous improvement all vital aspects. Boosting staff satisfaction and improving work relations requires extensive communication, as well as an alignment of the roles, responsibilities, attitudes and behaviors of everyone in the company.

Figure 27: Customer experience improvement levers

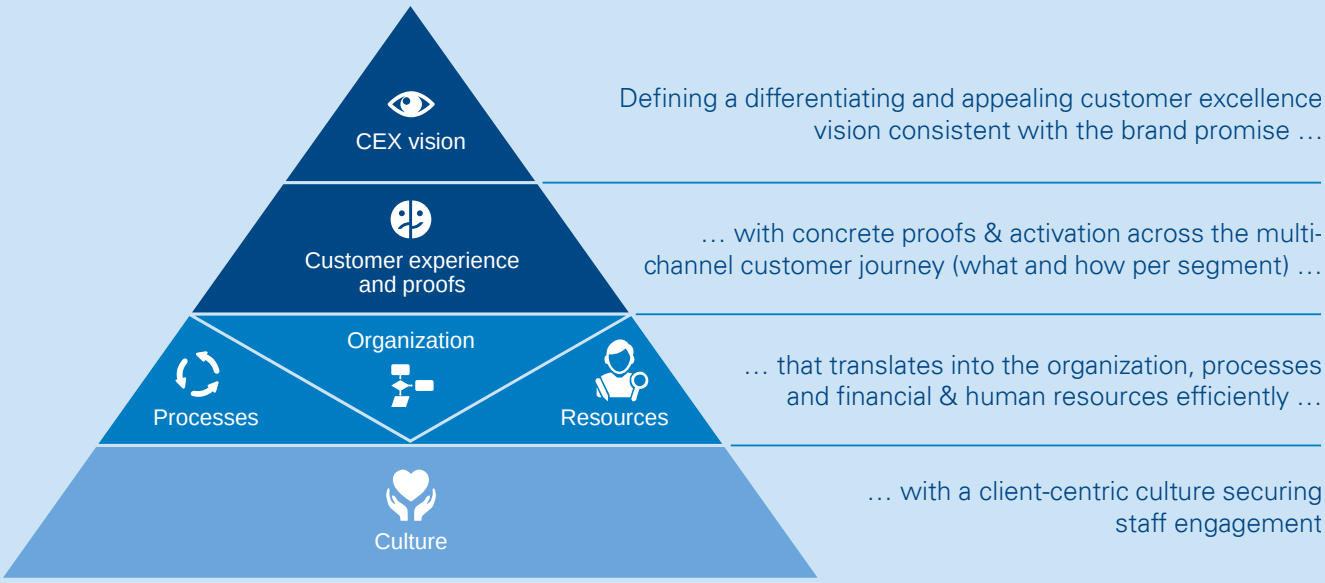


Source: Arthur D. Little

Approach to defining a customer excellence program (CEX)

The development of a holistic approach that ensures that CEX is embedded in the organization, in both its hard and soft aspects

Figure 28: Arthur D. Little Customer experience framework



Source: Arthur D. Little

Customer experience improvement typically follows a structured approach that proceeds from an understanding of performance and needs to the implementation of the required actions.

The first step is to analyze customer segmentation in the market and, following a review of the company's brand platform and its attributes, select groups of consumers to target. In such a context it is vital for industry actors to play to their strengths. Metrics such as customer satisfaction surveys offer a good guide to a brand's areas of high performance and help identify priority areas of focus.

Once a specific group of travelers has been identified, it is important to gain an understanding of their needs and requirements by mapping customer journeys, including both physical and digital touch points. After assessing the company's ability to meet their needs via a comprehensive internal and external review, a pool of appropriate solutions can be drawn up that takes into account aspects such as needs per segment and the operating and capital expenditure required meeting them. Of critical importance is finding the right balance between "fixing the basics" to eliminate drivers of dissatisfaction, ensuring a consistent approach across the journey and creating wow effects to exceed expectations at selected touch points. A customer experience matrix can be maintained by mapping existing and new ideas across the organization to maximize the experience into a program of continuous improvement.

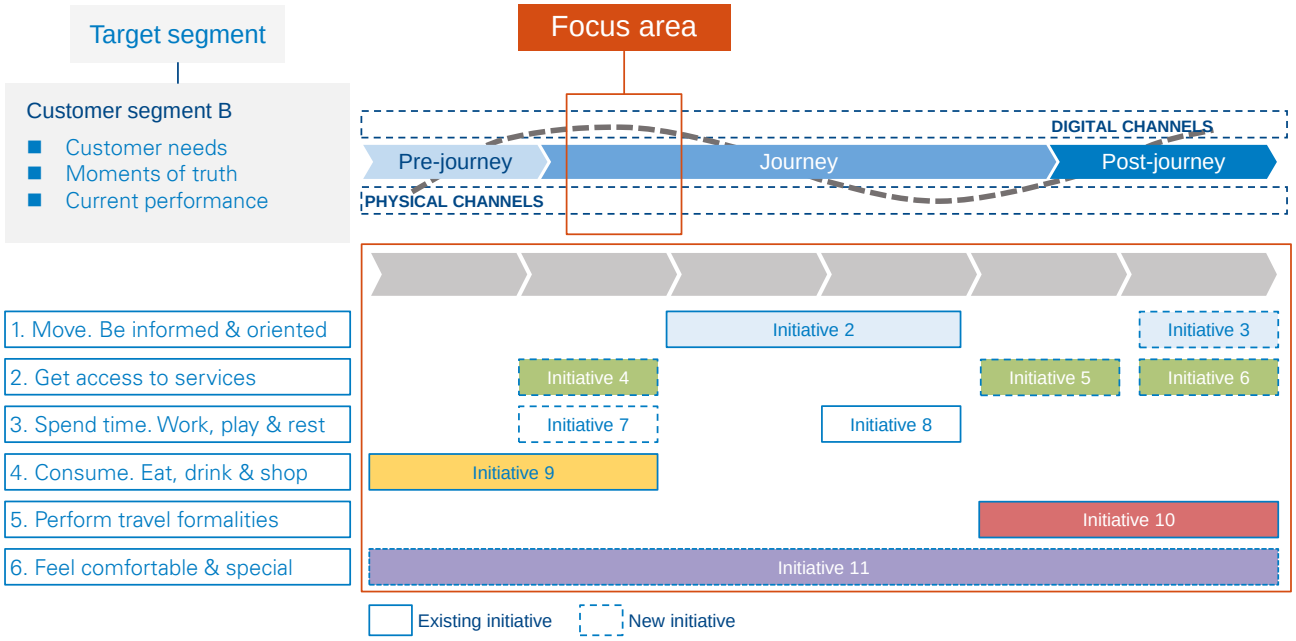
When the process gets to the roll-out stage, a close eye must be kept on the impact it has on the organisation's processes and systems. After all, prioritized solutions must be activated alongside ongoing and planned initiatives, and their progress monitored and adapted as necessary in line with a policy of continuous improvement.

Lessons learned from customer-experience improvement programs:

- Branded customer experience: Define a clear customer-excellence vision in line with brand values (see dimension 1: sense of purpose) and secure a common language and alignment on differentiation.
- Ensure the CEO – and more generally, the top management – is personally involved in setting an example when it comes to customer treatment, and maintain board-level visibility through regular upward and downward reporting.

- Ensure that the experience of employees as well as customers is given equal weight (i.e., through mirrored values and symmetry of attentions).
- Do not devote 100 percent of efforts to pain points: work on delighters!
- Create a customer experience department or experience center (with assumed counterweight positioning), and produce customer experience analytics to support each department or BU.
- Implement a selected set of customer experience KPIs, with appropriate frequency and precision.
- Empower employees through customer experience "ambassadors" (creating and enhancing a feeling of shared responsibility among all employees) and cascading training.
- Prove customer experience value is a "daily show" and translates into daily proofs at all levels of the organization.

Figure 29: Customer experience matrix



Source: Arthur D. Little, color code indicates responsibility for initiatives

5.2.4. Imperative #5: Redesign commercial offering

Commercial-offering redesign is key for mobility solutions providers to create differentiation vis-a-vis the increasing competition and adapt to a fast-evolving business environment.

Regulatory, technological and behavioral changes are transforming the mobility market:

- Regulatory changes are threatening existing monopolies in both rail and local public transport (e.g., driven in Europe by the 4th Railway Package and CE 1370/2007).
- Intermodal competition is increasing: a recent boom in more diverse service offerings means that new forms of transport are taking on traditionally dominant players. For instance, long-distance coach services (e.g., Flixbus, Isilines and Ouibus in France) are now seen as an alternative to traditional rail operators for long journeys.
- Industry 4.0 technologies are increasing market transparency, allowing smart comparison of offers and direct marketing to individual users (e.g., improved data analytics driven by artificial intelligence, the rise of customer-to-customer platforms and the sharing economy).
- Mobility behaviors are evolving, with increased polarization between "deal hunters" (who have little brand loyalty and seek out the cheapest travel options) and consumers of experiential/aspirational brands, who place increasing importance on the journey experience).

Recommendations on how to build a culture of service excellence[28]

Building a culture of service excellence is within the reach of all companies without imposing additional costs. One of the main challenges to achieving service excellence is probably finding the right balance between applying a standardized framework to quality of service and giving staff the freedom to deliver an ever-better customer experience: i.e., between mass-transit operations and individualized customer care.

The culture of service excellence is all about value (whether your customers and your staff feel valued, what customers value), mind-set and behavior. Below are our recommendations for success factors to consider when you are attempting to build a culture of service excellence:

- Ensure that top management maintains a strong and long-term commitment to building and strengthening the culture of service excellence, and brings intense leadership to the program.
- Engage people's hearts as well as their minds, as part of a comprehensive business culture.
- Make the human factor a central concern inside the company – in its structure, organization, communication and management.
- Involve all stakeholders, including representatives of staff, in the process of building a culture of service excellence.
- Define your value proposition in terms of customer experience – that means framing your service according to the experience desired by the customer at every step of the consumer journey.
- Implement continuous management improvement and reform initiatives to turn a traditionally rigid system into a more flexible and creative operational structure.
- Empower people to find solutions and create a virtuous cycle of continuous improvement that engages all staff.
- Move from a prescriptive management model to one that encourages greater responsibility, initiative and innovation from individuals.
- Develop a common language and a new way of doing things by enabling employees to exploit their own creativity and powers of innovation.
- Create channels that allow everyone to express themselves in their fields of responsibility in order to promote supportive dialogue. Never forget it is the role of management to create the conditions that give staff the opportunity to succeed through ensuring their involvement and commitment.
- Explain to employees what is expected from them in order to turn their tasks into meaningful jobs, and provide feedback and recognition on the basis of the performance achieved.
- Bring about long-lasting and far-reaching benefits for staff, company and customers by creating common ground around strategy, values, attitudes and behaviors.
- Lay out values and translate them into concrete attitudes and behavioral standards.
- Ensure management inspire and encourage staff, through leading by example and being persistent and consistent.

Case studies: Customer and service excellence programs[29]

1) Transport de Lausanne – A quality approach focused on the customer experience

Since 2015, Transport Lausannois has implemented a quality-of-service concept that is better aligned with customer expectations. The idea is that the customer not only wants to be satisfied with the attainment of particular results in relation to specific criteria, such as staff friendliness or punctuality, but also wishes to have an experience marked by both tangible and more emotional elements. The appreciation of this experience varies greatly, of course, according to each customer's expectations and even their mood at the moment they live the experience. And so Transport Lausannois analyzed the various stages of the journey, and on the basis of its findings, redesigned the experience that the company wished to bring to life for its customers.

The new concept was born out of the values laid out in its "Vision 2025", and it redefined its mission statement to read: "Transport from A to B and accompany the customer from A to Z". The idea is that the company not only transports its customers, but accompanies them during their mobility.

To this end, the company defined each stage of the customer path and identified a range of particular customer types (based on persona, customer segmentation, etc.). It then concluded

what it wanted to offer its clients in terms of the optimum travel experience. On this basis, the company redefined its services and the level of quality it wanted to offer.

The innovations introduced also worked from a management point of view, as the implementation of the desired customer experience unites employees around a common vision. For example, the evolution of sales points towards personalized advice centers in the field of mobility generally – not only public transport – which are complementary to what a digital application can offer, brings together not only client advisors, but also IT, maintenance and designers of buildings and customer spaces.

2) SMRT – Building a culture of service excellence in Singapore

To engender a culture of service excellence, SMRT – the leading multi-modal public-transport operator in Singapore – has created a sense of pride in its staff in the service of its commuters. Delivery-service excellence is about moving from concentration on system efficiency to a more commuter-centric approach, and that means eradicating rules and procedures that get in the way of staff taking the initiative to go the extra mile for their passengers and act appropriately in difficult situations.

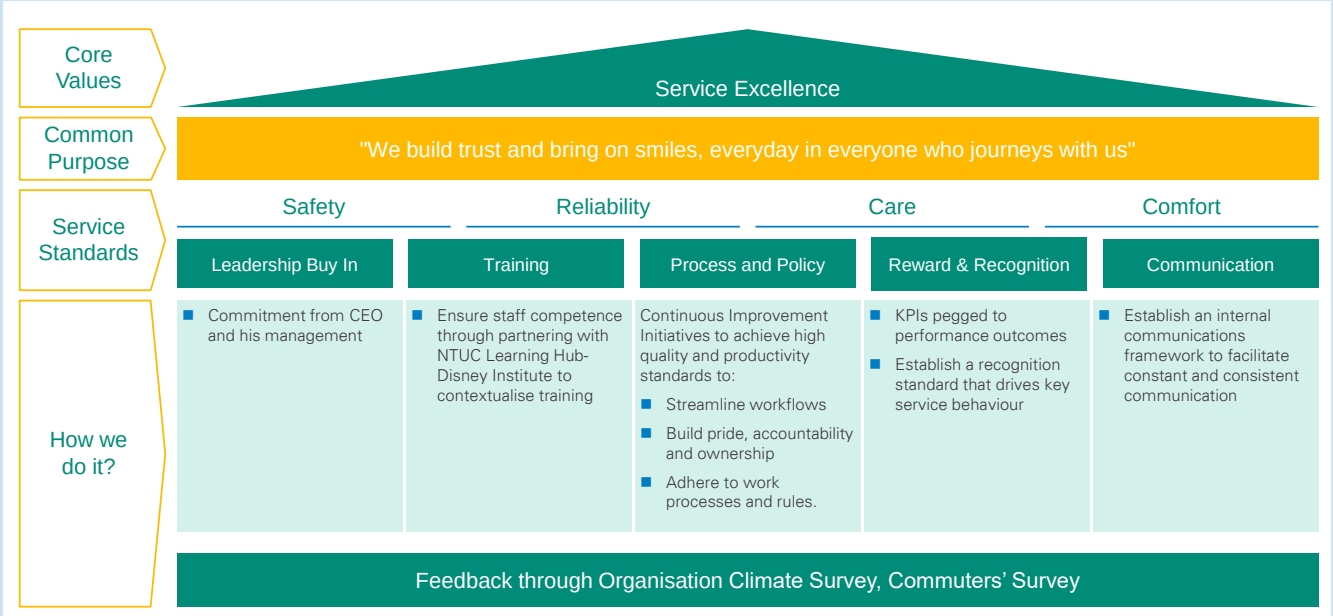
This culture is underpinned by a strong sense of purpose, strong leadership by example, a cohesive workforce, and very competent staff (who are nurtured by an initiative entitled the Service Excellence Training Programme). Recognition of performance and a continual engagement effort is also key to its success.

In terms of business culture, the objective of the company's HR transformation is to build professionalism and pride in order to deliver service excellence. In order to achieve this cultural change, SMRT unites all its employees around the following motto: "We build trust and bring on smiles, every day and in everyone who journeys with us."

To drive this transformation, SMRT deployed a company-wide service excellence campaign and training scheme, which was developed with the support of NTUC Learning Hub – the largest continuing education center in Singapore – and the Disney Institute in 2014. All 10,500 employees have been trained, from the CEO to every single Bus Captain.

The breakthrough strategy involved in this change of business culture was one which empowered staff to move away from the traditional binary "yes" or "no" approach to customers' needs and expectations to a more agile paradigm as they implemented the four key standards of service provision, which are prioritized as follows: safety, reliability, care and comfort. The goal is to make customers feel that they can count on SMRT staff to give them a positive customer experience.

Figure 30: SMRT – Building a culture of service excellence in Singapore



→ SMRT Innovative frame work in implementing service excellence

Source: SMRT

Traditional mobility solutions providers now face fierce competition from new and disruptive market entrants, including "over-the-top players" which are able to offer competitive fares by leveraging marketing and technology innovations. (See also Imperative #11: "Network the system" below.) There is a risk of commoditization of transport offerings, whereby consumer decisions are reduced to simple consideration of duration and price, while – in previously "monopolistic" markets – traditional mobility providers' prices may be off-market due to the new low-fare competition and the development of low-fare intermodal offers (e.g., carpooling and long-distance buses).

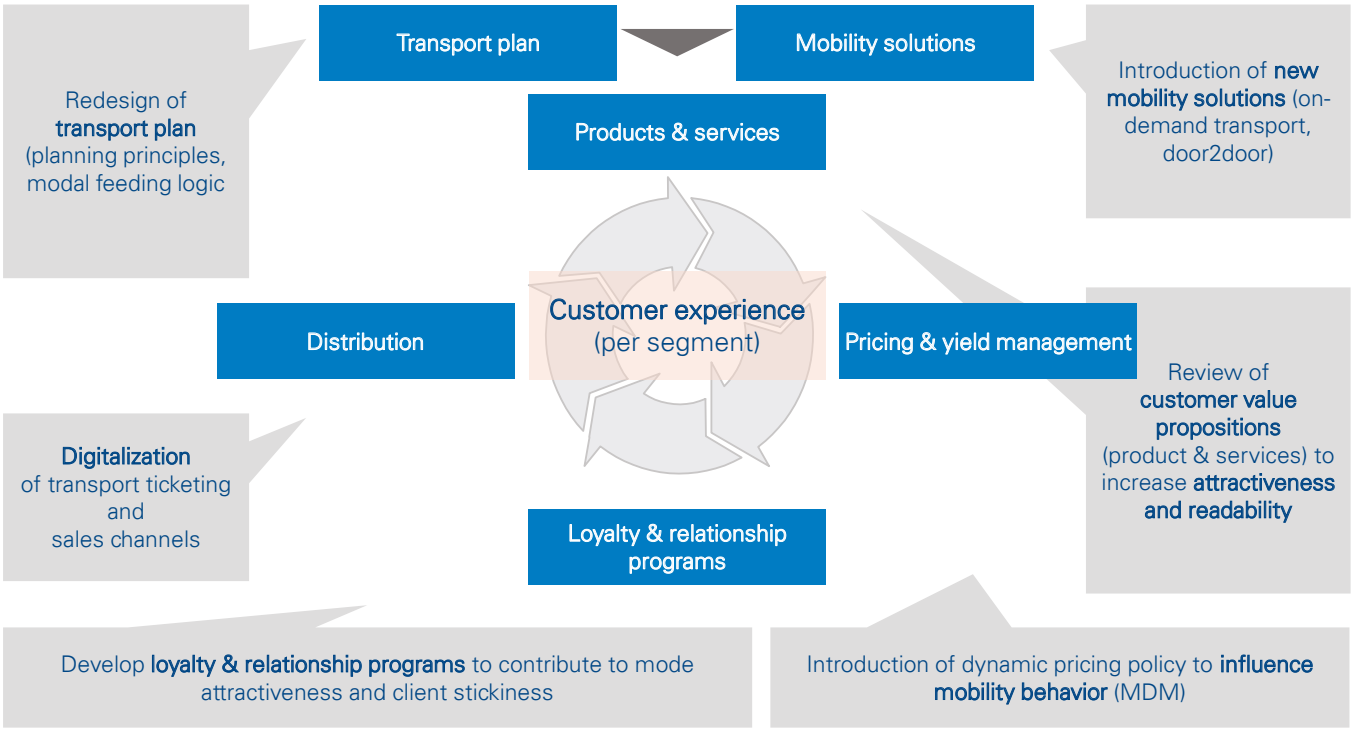
In order to avoid getting in a downward spiral, traditional mobility operators need to reinvent themselves, adapt their offerings and reinforce differentiation in order to develop customer preference, regain market share and defend the high-end markets, while at the same time keeping costs under control through redesigning their operating models. (See dimension 3: Operational excellence.)

From partial to full commercial redesign, mobility operators can activate several levers to improve the offering attractiveness, boost competitiveness and create customer preference and stickiness, as illustrated in Figure 31.

Each of the components of the commercial offering may contribute to improving the overall offering attractiveness and boost a company's competitive position:

- Redesign the transport plan (planning philosophy, connections and intermodal feeding logic) to ensure better alignment between the objectives required in terms of offering and the planning of the necessary infrastructure developments.
- Introduce complementary mobility solutions (such as on-demand transport), make the most of ongoing disruptions by anticipating and responding, consolidate the market, and digitalize and integrate service offerings through internal development, acquisitions or partnerships.
- Differentiate the customer-value proposition through the redesign of the offering architecture and increase the value proposition differentiation via product and services adaptation, with highly identifiable and segmenting attributes. Over recent years, several rail and metro operators have adapted their offering architecture and prioritized linear structuring of their offers to increase their readability and impermeability.

Figure 31: Dimension of commercial offering redesign



Source: Arthur D. Little

- Reinforce price competitiveness to address price-sensitive customers and assess opportunities to introduce dynamic tariffs through yield management for better mobility demand management.
- Create customer retention and client value through loyalty.
- Move towards more innovative and agile distribution formats to keep up with market trends.

Meanwhile, new players – in anticipation of the reaction of traditional operators – need to keep investing in new solutions and technology, and continually reinvent themselves to further challenge the entrenched operations of the more established market players.

5.3. Dimension 3: Operational excellence – "Improve operations' effectiveness and efficiency to create or maintain competitive advantage"

5.3.1. Introduction

The business and the environment in which mobility solutions providers are operating is changing rapidly and actors must continue evolving to stay ahead:

- As mentioned earlier, customers' needs and demographics are changing, and they have higher expectations of their journey experience.
- While the main unit costs (wages, infrastructure fees, energy) have risen continually in recent years, travel fares have often not kept pace. This has put many players, especially incumbent mobility solutions providers, under additional financial pressure of late despite many of them recording notable productivity increases.

Approach to commercial offering redesign

Commercial redesign typically follows a structured approach from understanding current performance across customer segments to defining and executing the commercial-redesign roadmap:

- Assess the current performance of each of the key dimensions of the commercial offering.
- Identify and prioritize evolution scenarios, ranging from soft to complete commercial redesign.
- Detail key levers for improvement and model their impact.
- Define an implementation roadmap (both towards the market and internally).

Before going into the details of a commercial redesign, we often integrate two introductory steps:

- The development of attitude-based customer segmentation (see Imperative #3) will contribute to the definition of an updated vision of the needs of key target clients in light of new consumption patterns, and help gear commercial performance towards them.
- A review of the competitive landscape and trends, including a benchmarking of the positioning towards key competitors (both intra and intermodal).

Our approach typically encompasses all key building blocks of the commercial offering, aiming at addressing the following questions:

- Requirements and constraints: What are the constraints in terms of the transport plan (ability, or not, to influence) and rolling stock (understanding of commercial and technical constraints)? What are the requirements in terms of public-service obligations?
- Structure of the offering (mobility solutions and underlying transport plan): How are the commercial offerings structured? In how many layers? Are the target clients for each offering clearly defined? How does each product perform? Is the structure of the offering easily readable by clients and prospects?
- Products and services: What is the overall quality of services, and how is it perceived by the customer? Are services attached to fares segmented enough, and do they enable customers to make true choices based on their preferences? How are cross-sell and upsell strategies executed?
- Pricing and yield management: Does pricing strategy enable the company to optimize value captured from customers? Is the pricing strategy fit for purpose when it comes to competing with emerging low-fare offerings?
- Loyalty program and CRM: Do loyalty programs really drive modal preferences and boost traffic? How does CRM connect with customer usages throughout the year?
- Distribution: How is distribution structured? Does the distributor's offering deliver on service quality and drive ridership, revenues and product differentiation?

Lessons learned from commercial-offering redesign programs:

- Your data is key: Go beyond declarative market studies and leverage your client database to get insightful analytics on customer usages and preferences.
- Simplicity may be the answer: Don't always be tempted to add layers – it may be preferable to reduce the number of offerings and put true choices in front of the customer.
- Differentiate your offerings: If you do not differentiate offering attributes (e.g., flexibility, internet-on-board services) within your fares, be prepared to degrade some of those in low-end product categories to drive your upselling strategy.
- Don't go too big on promotions: Too many last-minute hot deals can lead to large-scale cannibalization of the core offering, as they scramble customer perception of the value of anticipation.
- Capture occasional clients on loyalty programs: Think about creating exclusive counterparties, even for occasional clients, in order not to focus loyalty solely on frequent travelers and thus drive customer acquisition.

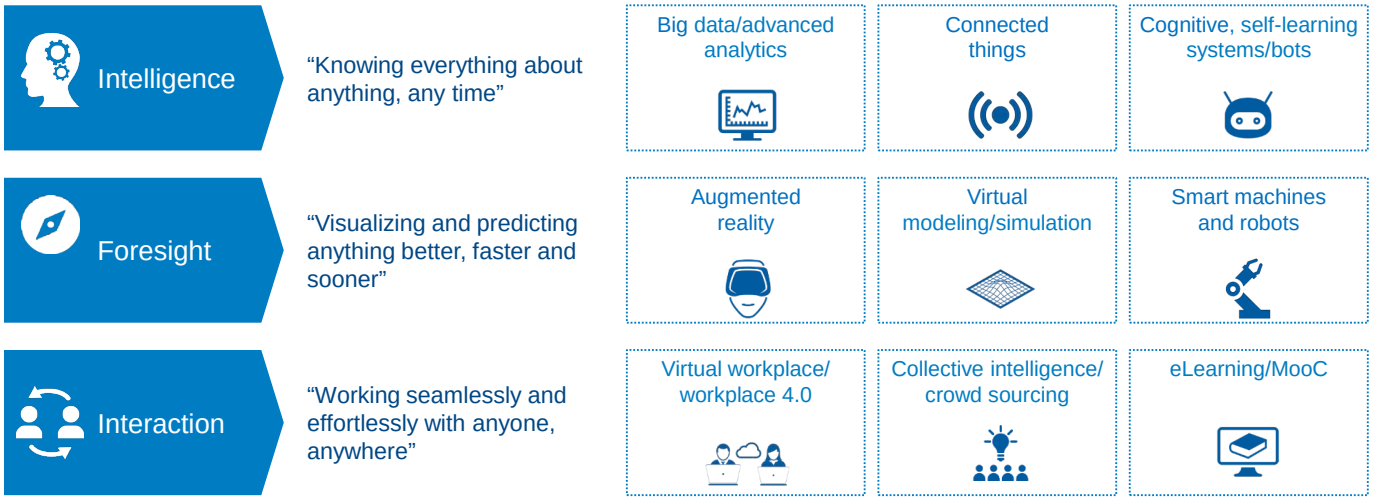
- At the same time, incumbent mobility solutions providers are facing fierce competition from new mobility players and solutions often operating from a lower cost-base and able to act with a higher level of agility. In order to maintain or strengthen their competitive position in this new world, mobility operators need to change the way they work to reduce operating costs.
- As ridership levels increase, mobility operators need to expand their networks while maintaining and improving service levels. At the same time, as their assets are aging, operators will have to replace much of their inventory, leading to increasing investment requirements, which will drive down their operating margins, or put further strain on taxpayer resources.
- But not only that – as technology is developing rapidly, the assets that operators will have to manage will also be different in the future and new competencies will need to be developed, for example in digital technologies, to manage the assets of the future while sustaining the important competences of those who are retiring.

Mobility solutions providers are evolving in an asset-intensive and long-cycle industry. The asset-management approach needs to accommodate these major expansions and changes, something that will require an integrated whole-system philosophy to manage both new and existing assets. The ability of an operating model to maximize the use of these assets and deliver effective and efficient solutions is thereby essential. An important imperative is thus to "improve the machine", by increasing the efficiency and effectiveness of operations while enhancing the utilization of assets:

- Reducing total operating costs ("cost per KM produced"): this can happen through, for example, increasing the availability of assets, reducing the cost of maintenance (e.g. a reduction in unplanned maintenance), adopting new ways to use rolling stock (e.g., smaller units which are less expensive to operate) and mastering long-term Capex planning and major asset-renewal and replacement.
- Increasing passenger utilization ("passengers per KM produced"). An increase in utilization (load factors) can happen through, for example, increasing the overall number of passengers (as discussed in dimension 2) and optimizing the transport plan via schedules adaption and mobility demand-management measures).

Operation 4.0 technologies are booming in the mobility sector, and the benefits of such technologies in terms of intelligence, foresight and interactions have no need to prove themselves anymore. (See Figure 32.) But before stepping into implementing solutions, the challenge for mobility operators is to select and prioritize their digitalization pathways through understanding the realm of opportunities and defining the right target picture in terms of operating improvements, taking into account company-specifics. This will allow operators to focus on prioritizing the implementation of levers that will have the most positive impact on both costs and improving customer experience.

Figure 32: Opportunities associated with operation 4.0 technologies



Source: Arthur D. Little

5.3.2. Imperative #6: Long-term Totex planning

The pace of technological development is accelerating. The inevitability of asset renewal and replacement, with their multiple root causes (e.g., end of life, lack of capacity, obsolescence), creates an unavoidable need for asset owners and operators to plan effectively their long-term Capex needs, based on a clear vision of what networks and operations will look like in 15 to 20 years' time.

However, the task of effectively forecasting and planning for long-term Capex requirements is far from straightforward. While a short- to medium-term plan – for example, over a five-to-seven-year time horizon – can serve as a useful roadmap, plans inevitably become less meaningful the further they project into the future.

Failure to effectively reconcile divergent views on what genuine future Capex needs actually are (beyond mid-life or the first asset life cycle) – especially between engineering, operations, finance and project managers – may further inhibit the attainment of a realistic view of long-term Capex needs and, crucially, needs that can actually be delivered.

While ownership structure can play an important role in shaping attitudes towards maintenance, renewal and replacement spend, shareholders – whether government or private entities – are unlikely to take kindly to sudden changes to long-term Capex forecasts. This can place an additional brake on the development of more realistic plans.

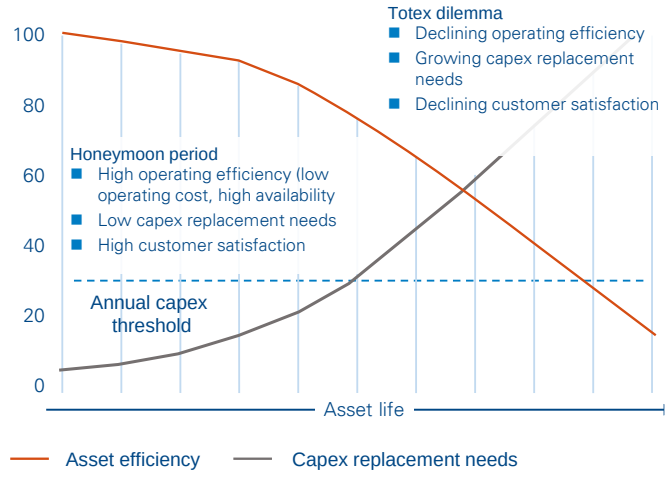
Left unaddressed, the barriers to effective long-term Capex planning can result in a particularly challenging situation for rail-asset owners and operators, characterized by what we refer to as the "Totex dilemma"[30]. (See Figure 32.)

The Totex dilemma is a situation characterized by:

- An aging asset base: many core operating assets approaching or exceeding design life in a similar period.
- Increasing operating costs, as a result of running core operating assets beyond their intended design lives and incurring incremental maintenance costs.
- A backlog of capital works, due to financial constraints, limited internal capability or capacity (e.g., possession of heavy rail trackside), or "crowding out" by capital projects, even when these receive separate funding.

Additional issues in the form of flat or declining operating revenues, and long-established customer expectations of service standards, may heighten the challenge faced. Thus, a dilemma arises when an organization is faced with growing Totex requirements and insufficient resources with which to meet these needs. While a long-term Capex plan may exist, it may well have ceased to be meaningful – such is the disconnect between need, resources and ability to deliver.

Figure 33: Totex dilemma



Source: Arthur D. Little analysis

It is critical to consider the set of factors below in order to overcome the "Totex dilemma" and lay foundations for efficient and effective operations:

- **Requirements capture:** The divergent views of engineers, operators and project managers can result in fragmented and inflated views of what an asset's required specification actually is, pushing up costs. In operational areas, with direct customer interfaces, such as ticketing, the failure to formally reconcile competing internal perspectives with the "voice of the customer" can sow seeds for sub-optimal CEX, performance and cost outcomes in later years.
- **Governance and control:** Complementing a more robust approach to requirements capture is the need for effective governance, control and prioritization of Capex-funding requests. Clearly, it is important to retain an element of flexibility to cater for truly urgent short-term needs. However, taken too far, this can create a culture of habitual capex deferral. A universally understood and enforced capital-expenditure hierarchy that clearly differentiates between types of Capex (e.g., renewal, replacement, commercial), and supports an effective interface to the finance function, is essential.
- **Incentives:** Changes to governance and control will only be effective if they are underpinned by the right incentives. These must address the unintended consequences of prevailing business rules and financial/operational targets. Participants must be encouraged to eschew political self-interest and engage in the process of forecasting Capex needs and securing funding in a way that best reflects the long-term needs of the transport system and its customers.
- **Enablers:** Effective Capex planning is not an isolated activity, but rather has interfaces and dependencies that are critical to many functions, not least maintenance, procurement and technology. Efforts to shape more realistic long-term Capex plans are unlikely to yield target benefits unless there are effective procurement and maintenance regimes in place. Capex plans must also be reflected in the technology strategy and vision, which should provide clarity on which Operation 4.0 technologies to invest in, and which not to. (See Imperative 8.)

By addressing the aforementioned critical success factors, mobility operators can take big steps towards the delivery of optimized Capex renewal and replacement functions that enable greater efficiency and effectiveness.

5.3.3. Imperative #7: Operating model redesign (transport and maintenance plans)

A future-proofed transportation plan is one of the critical components required by transport operators which are determined to find the right balance between maximizing revenues (through ensuring an attractive commercial offering) and reducing total costs per passenger-km while enhancing the usage of the fleet. Such a transportation plan is also indispensable to planning long-term investments and maintenance.

A transport operator's ability to keep a lid on the total cost of its operations is highly reliant on its ability to design and operate an efficient transport plan which sets out what is required of the other elements of the operating model, such as personal shifts, maintenance needs and infrastructure usage, while also determining the end-user offer.

Transport operators and, more specifically, legacy operators have traditionally run yearly transport-plan optimization processes based on incremental changes to the previous year's plan. These initiatives are usually assigned to the teams in charge of the day-to-day adjustment of the transport plan and rarely involve any radical changes to the levers and design methods. In fact, transport-plan design can be highly constrained at a very early stage of the process by the large number of contradictory obligations requested by different internal entities, e.g.:

- Formal public-service obligations, which constitute critical requirements.
- Other institutional obligations related to agreements with local authorities, which expect certain transport offers (in terms of the number of daily departures or connections to low-demand areas).

Case study: MTR's Foresight-driven Asset Strategy (FAST 2030+)

Hong Kong's Mass Transit Railway (MTR) recognized the need to transform its way of working in a world where the environment was changing, and technology was advancing rapidly. It developed a vision for how to manage its assets in the future and a transformation plan to enable it to get there, called FAST 2030+, with the objective of providing a consistently efficient, high-value service.

The assets of the future

The pace of technological development in metros and railways is accelerating. MTR's strategy for asset management needs to be based on a clear vision of what the railway will look like in 15 to 20 years' time in its home market.

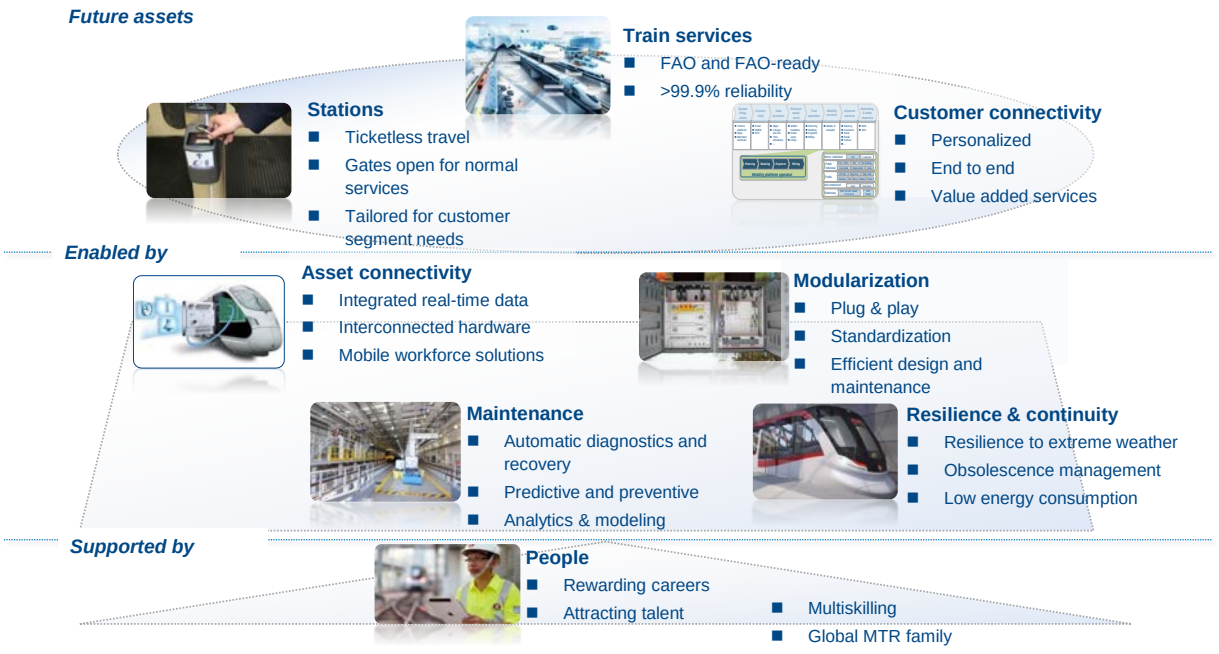
- The railway of the future must be highly reliable, with Fully Automated Operations (FAOs) or readiness for FAOs in the years to come. Stations will be further tailored to customer needs. Enhanced connectivity will allow more personalized and value-added end-to-end customer services.
- Connectivity will also enable new ways to maintain and manage our assets, with real-time data analytics for predictive and optimized maintenance, and increasing use of automation in responding to disruption and carrying out repairs. Modularization will allow for more efficient designs, and there will be new approaches for energy efficiency, system resilience and better management of obsolescence – which will be especially important as the penetration of short-life-cycle digital technologies increases.
- Finally, MTR considers that its most important asset is its people, and its strategy will ensure that it continues to attract the brightest and best individuals, develop their competencies for the future and offer them exciting and rewarding careers.

MTR's FAST 2030+ vision for asset management is designed to meet these challenges and support MTR's overall aim: "To be the world's best railway for service, profitability and innovation."

Focus on nine strategic priorities for change

MTR's strategy to deliver the FAST 2030+ vision aims at radical transformation of the way it manages assets. To deliver its vision, MTR will focus on nine strategic priorities:

1. **Foresight-driven active demand management:** Driving asset-management strategies and decisions through having a consolidated view of demand information.



Source: MTR, Arthur D. Little

2. **Fully integrated, real-time asset information:** An integrated asset-information system will be the key enabler of the rest of the strategy. This includes optimized and predictive maintenance, remote-condition monitoring and data analytics.
3. **A new technology and innovation management approach:** Active management of new technologies and innovations to better exploit their potential.
4. **New ways of working with partners and suppliers:** New partnership and collaborative approaches with suppliers to better leverage their capabilities.
5. **New approaches to minimize disruption impact:** Solutions to minimize their occurrence and impact, and to improve recovery.
6. **Whole life/system efficiency and optimization:** New optimization, value engineering and cost management approaches.
7. **Customer-centric asset management:** Aligning asset management better with the customer.
8. **Strategic competence management:** Managing competences actively to meet short- and long-term needs.
9. **Cutting-edge new technologies:** Employing innovative technologies to meet the objectives.

MTR will also put in place a new model for asset management, ensuring that it remains PAS55 and ISO 55000 compliant. The new model builds on the strengths of MTR's current model, and its core asset life cycle remains unchanged, but there are some significant enhancements reflecting the nine strategic priorities.

- Expectations regarding maintenance which affect temporal and geographical workload distribution.
- Slot availability as defined by the infrastructure operator.
- Type of rolling stock in the case of a heterogeneous fleet, all with different capacities, different rolling speeds and security equipment, and various comfort levels.

As a result, the design process inevitably replicates the past and establishes a transport plan with similar weaknesses and under-optimization factors to its forebears.

Today, increased competition from alternative modes of transport, as well as the prospect of regulatory liberalization in the future, means operators are pushed to reinvent their operational models in order to gain better control over their cost structure, while continuously investing in and modernizing their fleets.

Operators can achieve significant improvements through better utilization of their main assets, namely the fleet, which translates into maximizing the time vehicles spend in commercial use by:

- Minimizing parking time during the day.
- Minimizing maintenance constraints during the day, hence organizing most of the maintenance during the night, which can necessitate re-engineering of the overall maintenance guidelines.
- Limiting the number of intermediary stops, thus reducing the amount of get-in/get-off time.
- Avoiding any asymmetrical transport-plan construction which leads to non-commercialized traffic.

From our experience, the optimal way of redesigning a transport plan is to start from a blank page by first focusing on defining the industrial optimum, then optimizing fleet utilization, before progressively adding commercial and other constraints:

- The **industrial optimum** is obtained by focusing purely on optimizing the commercial use of rolling stock, which translates into a fleet being used continuously throughout the day. This scenario optimizes the number of seats available per vehicle and per day (i.e., decreases significantly the size of the fleet necessary to produce the day's required capacity). As things stand, vehicles are overbooked at peak hours and have very low occupancy rates the rest of the day. A valuable share of the traffic is lost, but this scenario optimizes the operational margin rate.
- The **commercial optimum** takes into account demand and adds vehicles to the industrial optimum as long they have positive margin contributions, which means this scenario typically does not address institutional obligations. A small share of the traffic is lost, but the saving in terms of fleet size can be substantial. This scenario optimizes the total margin value.

- The **target plan** is obtained by adding constraints to the transport plan, especially the institutional obligations defined by the public-transport authority, as well as requirements driven by public-service obligations. Some of these will only increase variable costs, but most will require increasing the size of the fleet, which will add significant fixed costs to the activity. This scenario optimizes revenues but decreases operational margin.

Redesigning a transport plan can radically affect all the company's operations (i.e., maintenance, drivers and on-board personnel), and potentially profoundly affect the commercial offering. So, in order to improve the operational model, it is vital to monitor the overall financial impact and model the revenue profile of the new transport plan (occupancy rate, average selling price), while improving the cost structure, hence monitoring the operational margin.

In addition to formulating a commercially optimal transport plan, which secures the offering's attractiveness and takes into account existing constraints (such as public-service obligations), it is also of critical importance to secure the operationalization of the target transport plan. This means that a revision of the transport plan cannot be made in isolation, and should be conducted in such a way that there is close collaboration between marketing, the planning division, the exploitation division and the maintenance division. All these departments should be involved from the outset to ensure proper operationalization of the new transport plan.

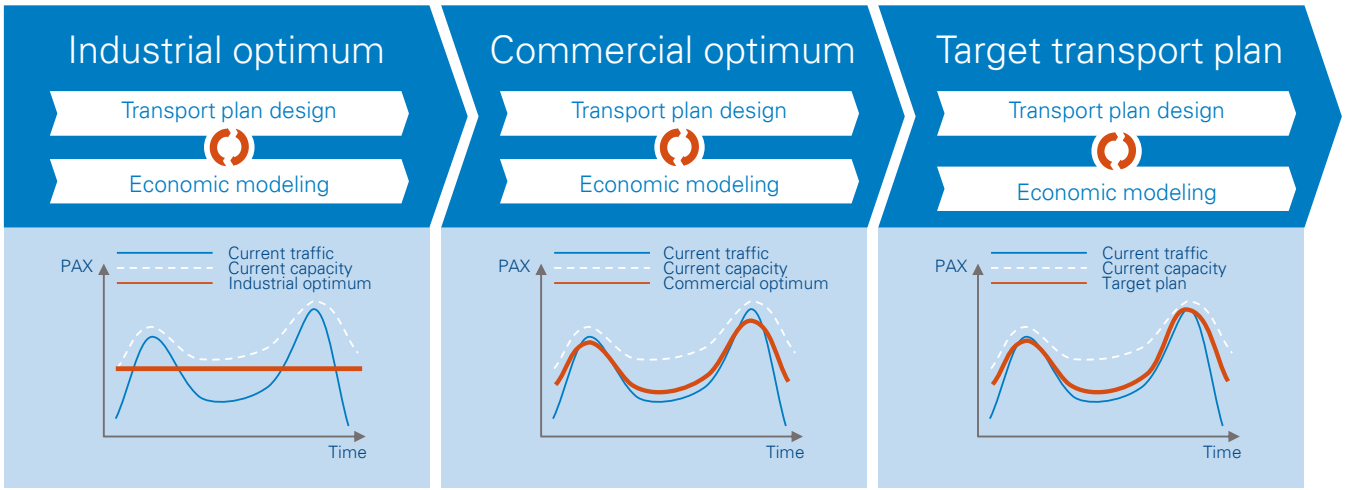
5.3.4. Imperative #8: Innovate for value

As briefly described in the introductory section, technology is shaping the future of mobility. A significant number of digital innovations have already been piloted or industrialized in the transportation industry.

We observe a number of established trends reinventing mobility across the value chain:

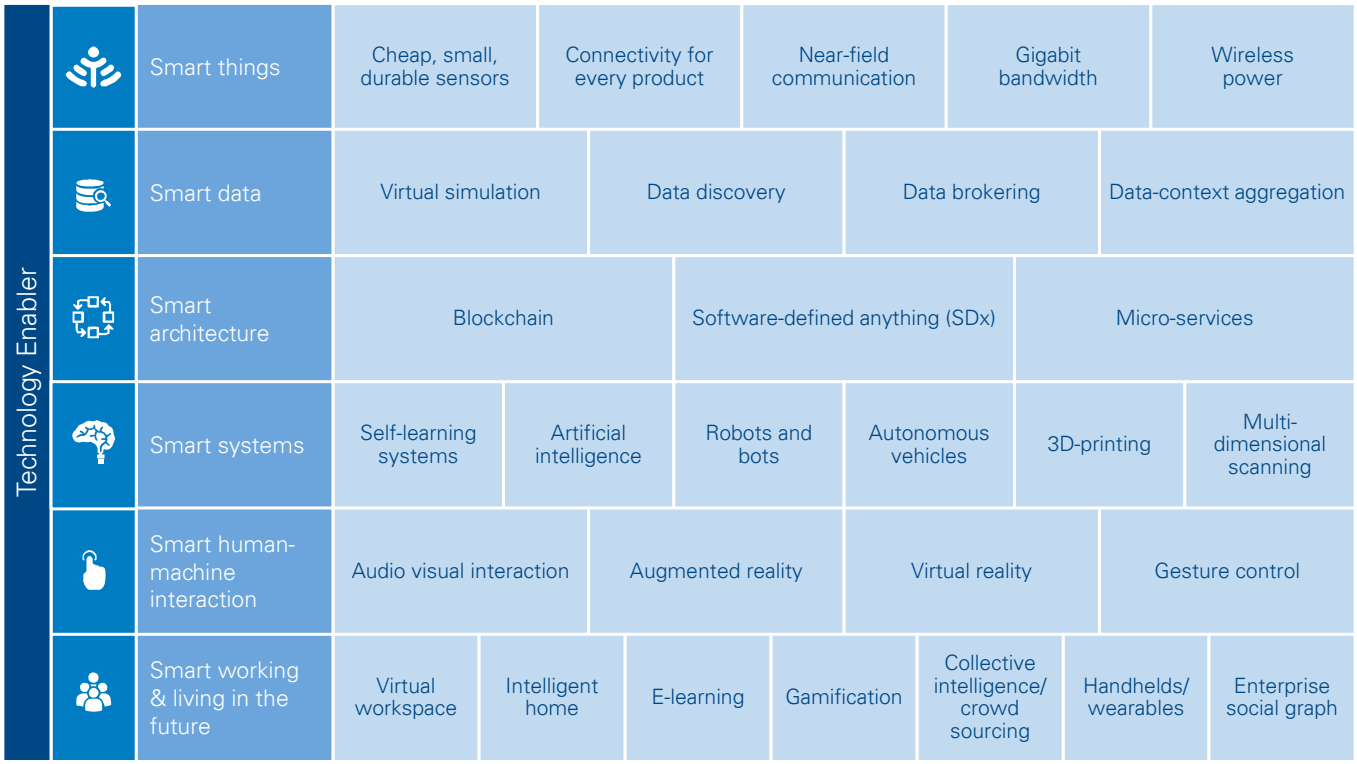
- Infrastructure and assets: Their use can be optimized by predictive analytics (including data-driven maintenance) and decision support. The use of augmented reality can enable remote asset inspection and reduce the costs of downtime. Collaborative asset management is enabled by real-time, company-wide data.
- Core transportation operations: The Internet of Things allows for autonomous transportation and smart-energy systems. Predictive analytics can support disruption management while improving safety, risk and capacity management. Real-time data will also enable remote diagnostics during service operations.
- Sales and customer: Automation is now giving way to cyber-physical systems that drive full connectivity, improved efficiency and customer experience. Digitalization is a strategic tool, leading to increased convenience for the customer and allowing activation of key digital touch points along the customer journey. In addition to this, for the operators there is the prospect of lower transaction costs, as well as lower maintenance operating costs and lower capital investment costs (e.g., less need to repair and replace ticket machines).

Figure 34: Optimal way of redesigning a transport plan



Source: Arthur D. Little

Figure 35: Current technology trends



Source: Arthur D. Little

- Business strategy and planning: Big Data is a critical lever in business development. Data ownership becomes essential to big-data capabilities and enhanced business planning agility. Predictive analytics and decision-support systems provide operators and authorities with the ability to perform more effective decision-making and "disruptive" business-model innovation, as well as providing third parties with data-led insight "on demand" to drive high-value partnerships.
- Support functions: In this area, self-learning bots are used to improve the automation of purchasing/inventory management. Big data is also deployed to manage customer and supplier relationships, as well as third parties and subsidiaries. Predictive solutions will also help to make better use of limited business-support resources.

Opportunities related to Operation 4.0 technologies can drive substantial lowering of the cost base and radical performance improvements. However, we often find that most of these opportunities only prove beneficial in the long run, therefore requiring mobility solution providers to secure shorter-term quick wins.

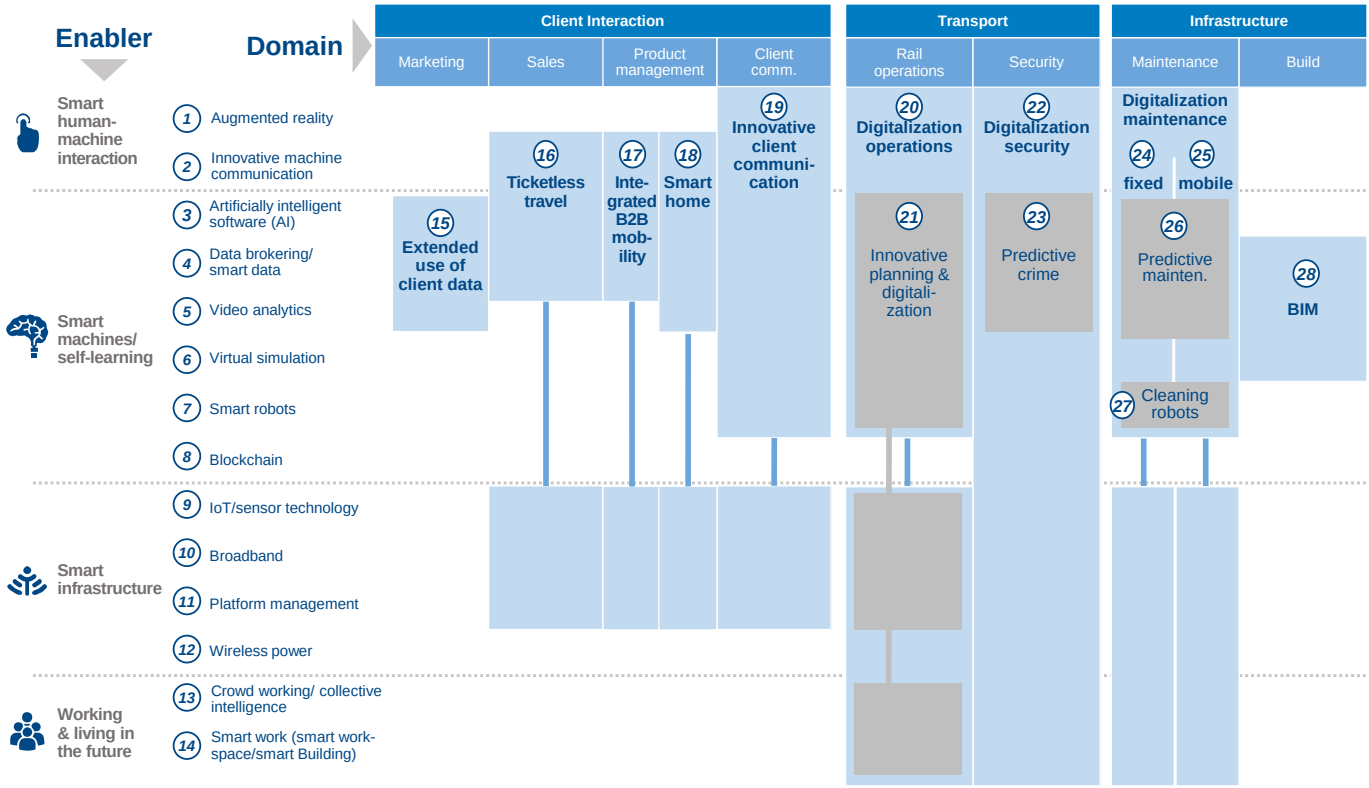
In order to navigate through this industrial transformation and grasp the breadth of opportunities, mobility solution providers will need to address several key questions:

- Which technologies and value-chain opportunities are available and accessible?
- Which applications of technology will bring the most value? And when?
- How will these technologies be applied, and how will they impact the operating model?
- How will the access to know-how and technology be secured?

A four-step approach can be used to help organizations answer these questions and define the most appropriate way to build a (often self-financing) transformation through digitalization:

1. Understand and identify core and technological optimization opportunities across the value chain.
2. Map possible opportunities to functions: define market and client requirements that need to be met. (See Figure 36 below.)

Figure 36: Technology mapping for a railway operator



Source: Arthur D. Little

3. Define target picture, assess the impact and set up proof-of-concept pilots to confirm priorities.
4. Define the transformation path and build backbone architecture: shape a holistic transformation roadmap and project pipeline to enable transformation towards the target picture.

The illustration above shows a heavily simplified version of a technology use-case map that Arthur D. Little created for a major rail operator. Against the key company processes on the horizontal axis, we have mapped 14 concrete digitalization use cases based on generic technology enablers on the vertical axis.

Some specific examples of use cases are:

- (20) Digitalization operations: Various use cases to digitalize operations using a vast range of base technologies – e.g., AI-based planning and disposition or the IoT to acquire a comprehensive and real-time view on assets in the network and their conditions. At the same time, digitalization can be applied to transform the daily business of staff in the field and in the office. Tomorrow's work environment will include elements such as virtual collaboration, crowd working, smart assistants, game stations and the automation of complex but tedious tasks.
- (23) Predictive crime: Based on data gathered, e.g., by smart video technology and evaluated with the help of AI, specific threats and dangerous patterns can be predicted more effectively or identified earlier. This helps to significantly increase safety in neuralgic points (e.g. trains, buses or stations).
- (24)–(27) Digitalization maintenance: Digitalization offers significant potential to completely reinvent the way asset maintenance is conducted. See the Focus Box on "digital maintenance" for a deep-dive into this matter.

Development of a target picture for rolling-stock maintenance

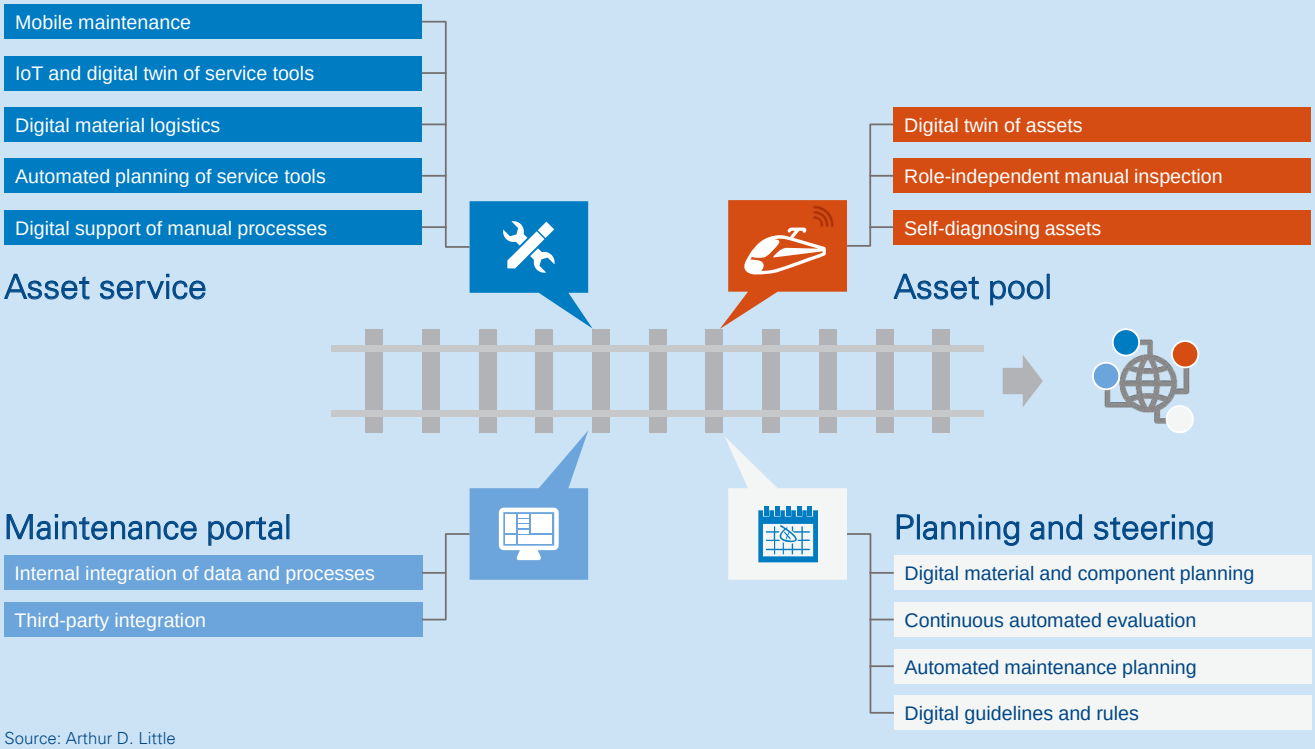
The effectiveness and efficiency of mobility solution providers is heavily determined by the quality of their asset maintenance, as this function is a key enabler of cost optimization flexibility, as well as product quality. A number of operators have successfully implemented solutions – such as predictive maintenance of selected train components, the IoT for logistics transparency, or augmented-reality applications within single procedures – to their day-to-day operational routines. However, clear target pictures for the extensive implementation of digital technology are rare, and many metro and rail operators still struggle to implement holistic approaches to automation and the analytics capabilities that govern short- and medium-term maintenance activities relating to their rolling stock.

The present business model of rolling-stock maintenance is being challenged by evolving competitive trends such as increased network-performance requirements, the flexibility of new market entrants and the further internationalization of potential suppliers. Our experience shows that many operators are aware of the potential risk to their businesses and follow several strategies to generate more efficiency within their production systems. These strategies, however, are often devoted to single business units and lead to disconnected approaches to the same target. We see four core challenges to the successful design of a rolling-stock maintenance model that cuts across corporate boundaries for the benefit of all involved parties:

- Definition of modular and standardized service offerings through all maintenance sites and asset types.
- Facilitation of live information availability over the whole value chain.
- Implementation of fully digitized process-support applications.
- Creation of end-to-end maintenance capabilities and their integration into all routines.

Our experience shows that companies often do not have comprehensive roadmaps to guide the roll-out of digital maintenance over their whole fleets and lack overviews of business-unit initiatives designed to digitalize single process

Figure 37: Maintenance of the future target picture



Source: Arthur D. Little

steps. While it is essential to generate advanced analytics and IoT-based data to provide transparency for a condition-based maintenance (CBM) approach, a centralized maintenance portal also needs to conduct direct diagnostic monitoring in real-time, and then forward all the necessary information to planning and steering, as well as service entities.

When implementing a target picture it is imperative to design a governance and operational model for future coordination, as well as to align all digital maintenance initiatives with the relevant business units.

To showcase the benefits of the model, lighthouse pilots for proof of quantification and further specification of the vision, especially in regard to the existing assets, are recommended. The key to identifying a pilot is to choose the right digital maintenance pilot plant, where the variety of serviced assets is low (e.g., a single train type), and thus existing processes are already highly standardized. The main optimization levers for the pilot to identify the value added should be split on the basis of costs (labor and materials) and quality effects (optimized availability, higher customer satisfaction and maintenance revenue increase).

"Blockchain – Which opportunities for mobility solutions providers?"

At a time when the mobility industry is facing a series of new challenges, Blockchain technology could be a key factor in facilitating the rise of new mobility ecosystems, innovative revenue streams and a reconfiguration of value generation.

In its most basic form, blockchain technology eliminates intermediaries and information asymmetry by providing all information to all actors in the network. To achieve this, blockchain technology records data/information as transactions. These transactions are then stored on a ledger ("the blockchain"). Instead of this ledger being stored centrally, the ledger instantly duplicates across all actors (nodes) in the ecosystem, ensuring information symmetry. Encryption is used to ensure that not all data is instantly public. This architecture allows for several key benefits for corporations in the mobility industry (and beyond).

- Intermediaries are eliminated – transparency is ever-present and the relationships between ecosystem players are simplified.
- Actors in the ecosystem can be trusted – even if they are unknown to each other.
- Transaction costs are marginalized.
- Processing time is almost eliminated.
- Information is secure and its integrity can be assured – individual data is safe.

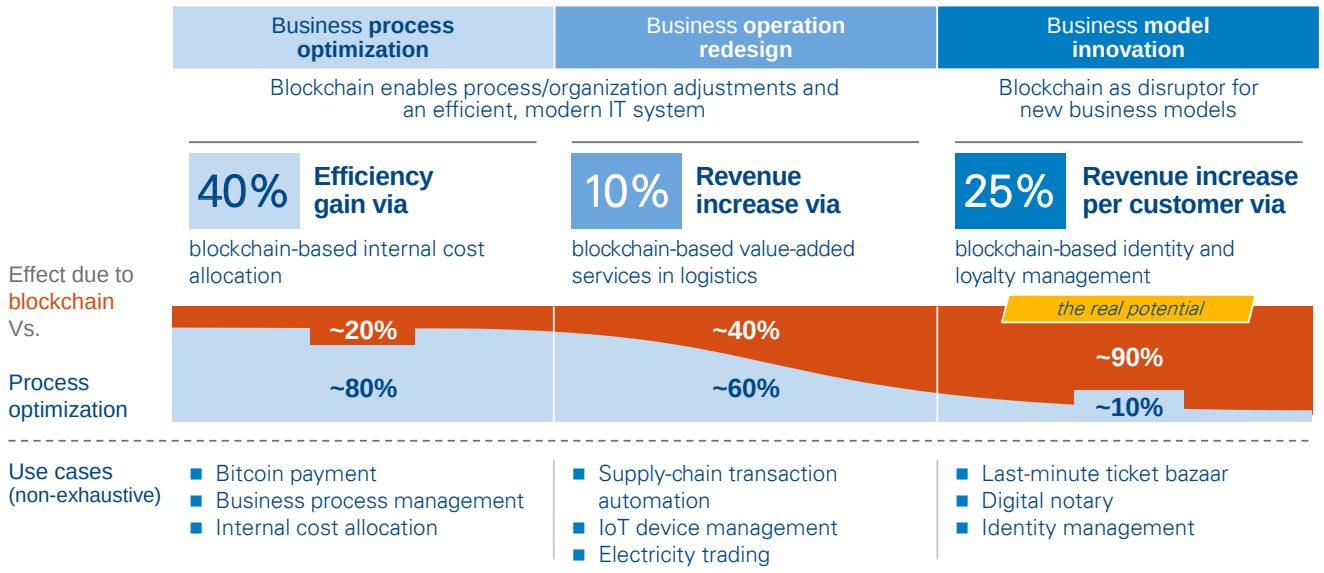
These benefits can affect organizations in three dimensions: business process optimization, business operation redesign and business model innovation. While the latter category enables all new use cases and products, as well as unlocking new income sources, the optimization of processes and redesign of operations have positive impact on the distribution of value, and thus, value-creating activities.

For each of the three dimensions, Arthur D. Little has recently worked out specific use cases for the mobility sector, as the chart below illustrates:

- Business process optimization: In this case, blockchain acts as an enabler for the digital transformation of processes, such as the validation of driver identity in car-rental companies – a traditionally time-consuming process that adds little value. In a recent project example, Arthur D. Little identified the potential to increase efficiency for internal cost-allocation procedures by approximately 40 percent.
- Business operation redesign: Use cases in this dimension have the potential to change the actual operations of companies. This allows for the creation of new partnerships, for example, as the technology enables a simple and native way of splitting revenues in ecosystems for multi-modal transportation, or by eliminating the need for existing steps in the value-creation chain, such as brokers (e.g., drive-hailing platforms with no real assets/drivers). Within this dimension, we have identified a use case at a logistics company that could generate up to 10 percent additional revenues from new services created.
- Business model innovation: Finally, blockchain technology enables radically new business models that change the nature of products or services and companies. In the context of car sharing and autonomous driving in particular, blockchain has the potential to change the

prevailing logic by enabling the rise of new players. A vision in this context is to have actors that only provide vehicles initially, while the vehicles themselves identify riders, create revenues (i.e., peer-to-peer transactions) and manage their own maintenance independently. For a large mobility provider, we have recently worked out a use case that promises around 25 percent additional sales through creating a customer ecosystem that allows it to sell additional services along the transportation chain in a convenient way.

Figure 38: Blockchain – Optimizing organization and creating future business



Source: Arthur D. Little

5.4. Dimension 4: Ecosystem integration towards Mobility-as-a-Service

5.4.1. Introduction

An analysis of the maturity and performance of mobility systems worldwide[31] has shown that, due to the complex nature of the problems at hand, separate optimization at sub-system level has strong limitations, and only system-level improvement will significantly improve overall mobility performance. However, in most of today's mobility systems, means of transportation are often still divided, and public and private stakeholders do not work together sufficiently closely on the development of seamless and networked mobility ecosystems.

Alongside regulation, we expect digitalization to be one of the main factors driving convergence and upgrading mobility systems to a completely new level. While many public authorities and traditional public-transport operators do not move quickly enough to regulate and make effective changes to bring about truly connected mobility, the digital revolution might actually be imposed upon them through other digitally enabled players, leading to a gradual evolution towards "Mobility-as-a-Service".

"Mobility can now be seen as an information service with physical transportation products, rather than a transportation product with additional services."

(The Role of Regulation in preparing Transport for the Future: Study for the European Parliament, 2016)

The concept of "Mobility-as-a-Sservice" (MaaS) aims to provide consumers with integrated, flexible, efficient and user-oriented mobility services. It implies a shift away from the personal ownership of individual motorized transportation modes, and non-integrated means of transportation towards the use of integrated multimodal mobility solutions consumed as services. This shift is enabled by combining transportation services from public- and private-transportation providers through an "integrated mobility platform" that creates and manages the journey and integrates planning and payment (based on mobility packages tailored to the needs of each customer segment) on a one-stop-shop principle[32].

The high expectations of the concept of MaaS are fueled by the anticipated evolution from ownership of a personal car towards consuming mobility through a combination of on-demand mobility services, which are expected to become significantly more affordable once self-driving vehicles are widely available. Note that while the concept of MaaS has – until now – been largely applied to individual mobility, it can be applied for the same reasons to the movement of goods.

All mobility stakeholders are likely to benefit from the implementation of the concept of Mobility-as-a-Service:

Consumers:

- Improvement of overall mobility experience through facilitating optimal mobility choices based on travel time, cost and other personal preferences, such as preferred departure time or a desire to make green choices.
- Reduction of the overall budget allocated to mobility – essentially by moving from a car-ownership model towards a mobility-usage model.
- Eventually taking part in the sharing economy.

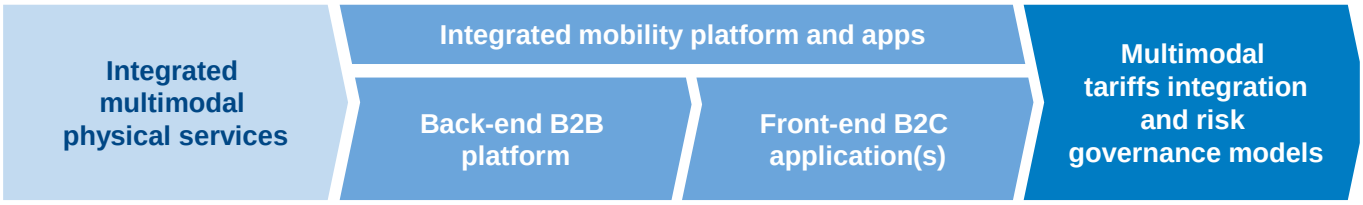
Transport authorities:

- Optimization of both investment in transport infrastructures and the usage, productivity and efficiency of both public- and private-transport solutions to the benefit of the system,
- Ability to orient transport policy towards more sustainable mobility modes, whether public (public transport) or private-driven (e.g., new shared mobility solutions).

Mobility solutions operators (public and private):

- Real-time optimization of the mobility offering and mobility demand,
- Access to all expressed mobility needs, thereby increasing the addressable market and making their services more accessible, which allows for an improved coverage rate. This

Figure 39: Components required for comprehensive MaaS deployment



- Well-integrated physical mobility infrastructures and solutions
- Multi-modal transport masterplan (incl. timetable synchronization)

- Central multimodal B2B back-end platform optimizes trip allocation, routing, payment and tracking
- Accessing data from individual operators and connecting to physical devices executing the transportation

- Front-end application (customer interface) with integrated functionalities for:
  - Information
  - Routing
  - Booking and ticketing
- Providing on-demand additional services

- Multimodal tariffs integration ("single tickets") risk governance model for third-party services
- Integrated payment system (pay as you go, pre-paid packages, monthly fee)

Source: Arthur D. Little

holds especially true for new mobility solutions providers for which customer acquisition costs can constitute a barrier to growth.

Full development and implementation of Mobility-as-a-Service at city or national level requires the presence of several components, as illustrated in Figure 39 below.

Well-integrated physical multimodal mobility infrastructures and solutions are a prerequisite to a well-functioning MaaS concept. Achieving this requires long-term alignment between mobility stakeholders on a common mobility vision and strategy, and a coordinated approach to investments. The development and implementation of a multi-modal transport master plan, which ensures the optimal allocation of transport modes in space and in time, will benefit the system as a whole.

At the center of MaaS is the integrated mobility platform and application(s). These will allow for the creation and management of journeys and act as an interface with consumers. Several possible evolution scenarios and business models are possible, each with their own advantages and disadvantages. (See box "MaaS evolution scenarios and opportunities for mobility operators".) Transport authorities and operators alike must carefully evaluate those scenarios, as the model selected will likely influence the overall outcome.

Also of specific relevance is multimodal tariffs integration and the associated requirements in terms of risk-sharing governance, especially in the case of a evolution towards a full "usage" mobility subscription model in which the MaaS operator would bear responsibility for the overall journeys, including the parts that are provided by third-party mobility operators.

Public-transport authorities have critical roles to play in the enablement of the MaaS concept at city or national level, and in ensuring the necessary conditions for success are in place:

- Defining integrated and multimodal mobility plans and making arbitrage for investment in public- and road-transport infrastructures.
- Providing, through regulation, access conditions and guidelines for new mobility solutions providers, which have a critical role to play in the implementation of MaaS.
- Defining rules of the game in terms of an open-data policy for public transport and the provision of access to the application programming interface (API) required for the development of back-end platforms.
- Finally, and most importantly, public-transport authorities have a critical role to play in setting up the right governance mechanisms to ensure MaaS operators strive for the "system optimum", allowing optimization of the mobility system as a whole by taking an agnostic approach to different transport modes.

Mobility solutions providers also have a critical role to play as increased convergence between (public and private) providers is critical to enabling gradual evolution towards Mobility-as-a-Service. We look at three specific imperatives below:

- Integrating the system: Contributing to the development of integrated and multimodal mobility visions and an integrated transport master plan.
- Opening the system: Collaborating with other solutions providers to better manage relevant mobility data (as input for the defining of mobility offerings in line with mobility demand), and contributing (along with transport authorities) to setting and applying a data- and API-sharing policy.
- Networking the system: Taking a leading role or participating as a third party in the development and implementation of integrated mobility platforms and applications.

Moving forward, we foresee that cities and nations will further push towards developing integrated master plans and leveraging the value of big data, translating them into customer-oriented offerings under Mobility-as-a-Service concepts. These will eventually integrate with overall smart city platforms, hence contributing to an end-to-end smart-city ecosystem, representing the basis for the concept of "future cities".

5.4.2. Imperative #9: Integrate the system (vision and transport master plan)

The importance of developing a political vision and a list of mobility objectives based on strategic alignment between all mobility stakeholders has been stressed in prior versions of the Future of Mobility report as a key imperative for public-transport authorities[33].

With the evolution of mobility needs and usages in recent years leading to an increased number of multimodal journeys, a critical enabler of a sustainable mobility vision is intermodal integration. Nevertheless, in most cities one can find road and public-transport networks that developed piecemeal in the historical absence of comprehensive and long-term master plans. As a consequence, most public-transport networks are insufficiently integrated with other mobility options, making it tough to challenge individual modes of transportation with credible

alternatives, especially for short-distance trips in areas not well covered by public transport.

This situation has led to:

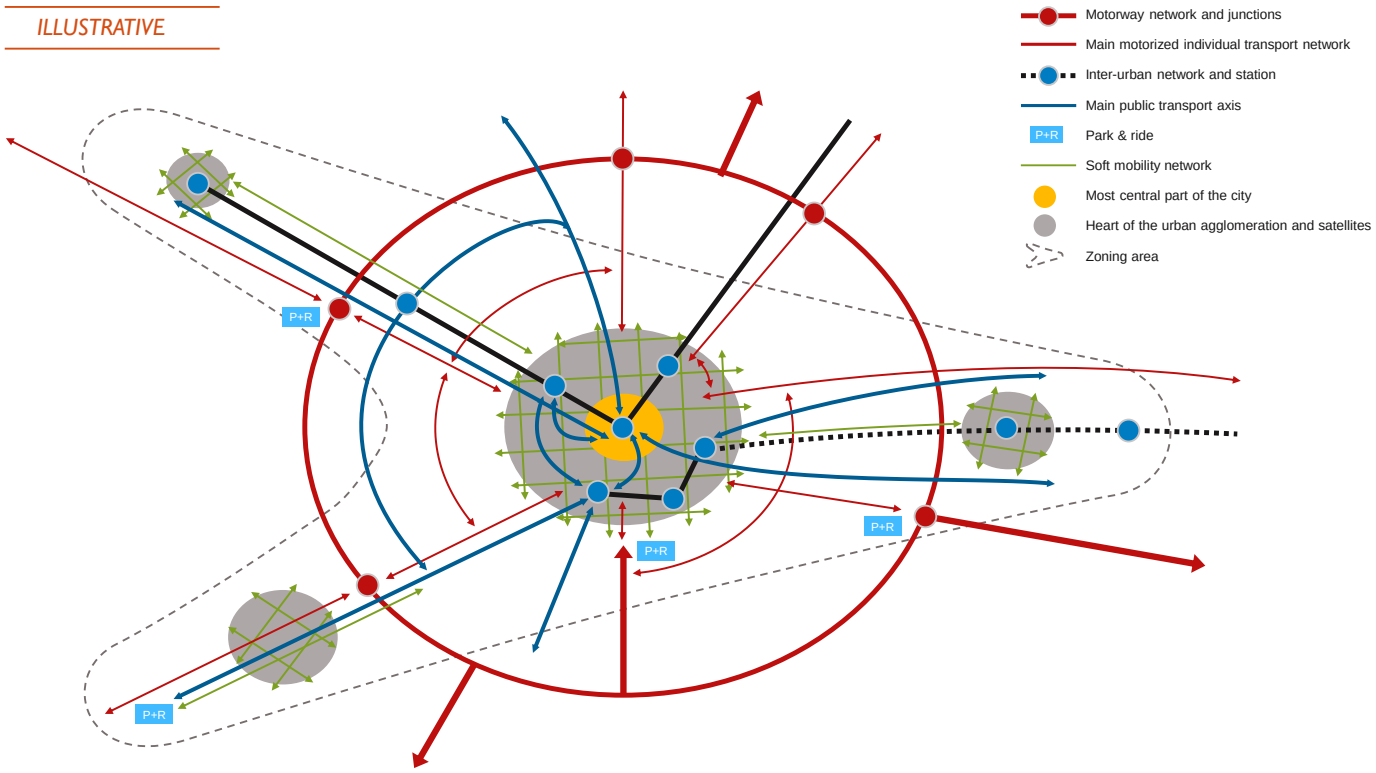
- Unattractive public-transport systems as both door-to-door travel times and the predictability of multimodal trips are deteriorating due to lack of physical integration (e.g., intermodal infrastructures), lack of synchronization of timetables across transport modes, and an overall decline in the customer experience.
- Sub-optimization of mobility systems' capacity and related capital and operating costs.

The concerted establishment of an **integrated transport master plan** at city or national level is a key imperative when it comes to improving overall mobility performance and attractiveness, through – on the one hand – the optimization of infrastructure and transport-solutions usage in "system" logic and – on the other hand – increased ease of use of the various networks collectively.

In addition to an alignment between accountable public-transport authorities (within and across city or regional boundaries), the development of such a master plan requires public and private mobility operators to contribute actively to its development. This involvement from operators is critical to ensuring that the best technical solutions and balance between different transport modes are found for the benefit of all consumers, as they are not swayed by – often short-term – political considerations.

An intermodal transport master plan allows better complementarity and usage (readability, experience) of transport systems, and reinforces inter-modality through better prioritization of transport systems according to their roles. Such a master plan is typically supported by two pillars:

Figure 40: Towards multimodal transport master plans at city, region or even national level



Source: Direction générale de la mobilité, Etat de Genève, "Mobilités 2030, stratégie multimodale pour Genève", 2013

- A multimodal transport vision (at city, region or even national level) encompassing all transportation modes and structurally improving connection nodes, while adjusting operating modalities to the nature of flows. (See Figure 40):
- Prioritize choices for sharing public space.
- Complement the existing transportation network grid (roads, railroads, water routes), specifically where multimodal added value is demonstrated.
- Establish complementary and strategic infrastructures,
- Strengthen and develop intermodal (e.g., multimodal exchange, connection nodes).

- Guidelines for timetable synchronization: e.g., the progressive application of a networked, fixed-interval timetable on the railway network around connection nodes, the adjustment of regional and local operators' timetables to railway timetables, the development of single ticketing, and the launch of a unique, multimodal public-transport fare.

Failing to implement this imperative will result in increasingly difficult negotiation conditions over the sharing of space to serve the various uses and interests, and could well ultimately lead to an unsatisfactory trade-off. What's more, without a holistic view of network articulation, a mobility development solution would have only limited impact given the fragmentary nature of its developers' views.

Case Studies: Multimodal transport masterplans

1) Oslo Integrated Multimodal Transport Masterplan

The city of Oslo established an integrated multimodal transport masterplan that helps increase the competitiveness of business and industry, improve traffic safety, make the transport system accessible to as many users as possible, limit the transport system's environmental impact and aids the transition to a low-carbon society.

Oslo's transport plan relies on exploiting the advantages of each transport mode (road, rail, air, sea) and strengthening the interaction between them to facilitate the efficient use of resources.

In that context, the city of Oslo has also been deploying a number of successful initiatives:

- Use of electric renewable energy to power half of its rail operations.
- Development of new products following a co-construction with citizens.
- Launch of the RuterBillett application that allows passengers to buy tickets online with 82% customer satisfaction.

2) Greater Manchester 2040 Transport Strategy

Transport for Greater Manchester is the integrated transport authority for Greater Manchester.

It has developed a comprehensive Transport Strategy 2040 that served as basis for the development of Greater Manchester multimodal transport masterplan. The Transport Strategy 2040 aims at shaping and creating a successful and resilient region, ready to tackle the challenges as well as the opportunities of the 21st century.

The strategy is comprehensive, articulated around the development and growth of the city, and address all key aspects of mobility in the city: Establishing Greater Manchester as a modern, pedestrian- and cycle-friendly City Region:

- Offering flexible and customer-focused travel choices, supported by smart information, ticketing and payment systems, for an integrated Greater Manchester transport network.
- Increasing reliability and safety of the road system for all users, including freight and commercial traffic.
- Building upon Metrolink and the improvement of commuter rail through the delivery of new and enhanced rapid transit links along with a transformed local bus network.

The integration of Manchester in the regional transport network of the North of England and its interconnection with the rest of the national network is fully part of the strategy, which include transformational investments such as HS2 as well as new and faster east-west rail connections across the North.

Case studies: Multiple stakeholders open collaboration platforms

In addition to working towards better integration between the different transport modes and increased sharing of relevant data to the benefit of all, it will be necessary to develop superior mobility systems, increase collaboration between (public and private) stakeholders to foster lateral learning and develop innovative mobility solutions.

In recent years, the concept of open collaborative platforms has gained momentum in the mobility industry. These platforms have been often introduced by traditional mobility operators or infrastructure managers who appreciated the need to reinvent themselves and liaise with actors of all sizes – often start-ups – to shape together the future of mobility.

We describe below a few recent examples that may provide good inspiration for others.

1) The Open Traffic Partnership (OTP) in south-east Asia helps public and private sector players join forces to solve traffic problems in some of the world's fastest-growing cities

- The purpose of the Open Traffic PPP is to create partnerships between governments and the private sector to use traffic data effectively in order to shape their transportation futures in a way that ensures equitable and safe access for all.
- Building on the success of the Philippines Open Traffic pilot program in 2016, the World Bank – along with a number of rideshare companies and mapping and navigation services – has launched the Open Traffic Partnership (OTP) to develop the global architecture for combining anonymized traffic data.
- The OTP launches various initiatives such as open traffic pilot programs (Philippines, 2016) and open traffic hackathons (Malaysia), data partnerships, data science for urban mobility and other new incubated programs. Initiatives focus on open traffic collection and analysis: traffic signal-timing optimization, optimal commuting-time analysis, congestion analysis and travel-time surveys.

2) Deutsche Bahn Open Innovation Initiative seeks solutions for key challenges defined by DB's production business units

- The DB Innovation Challenge was launched in 2015 in order to help identify solutions for innovation needs as defined by Deutsche Bahn's production business units.
- Definition of search fields in close alignment with business units (infrastructure, stations, long-/short-distance, cargo).
- Big corporates, small and medium-sized companies, and start-ups, as well as academics, were invited to DB's open innovation initiative to hand in their ideas and improve and tailor them in a cooperative and rapid way.
- The initiative culminated in the DB Innovation Challenge Award, where the most promising solutions were recognized at the Innovation Day at InnoTrans fair in Berlin. Winners were chosen on the basis that they had solved the defined problem/innovation need and thereby increased profitability, quality, flexibility and/or image.
- Winning solutions included: Volumetric testing of fiber composites by means of ultrasound; Bundle of Volumes "Modern Diesel Engine"; and Automatic shift-plan creation based on employee preferences.

3) JR East's Mobility Innovation consortium to build the next generation of public-transport systems

- As part of its Vision 2030 "Revolution in Mobility", JR East – the East Japan Railway Company – committed itself to contributing to solving future social challenges, such as an aging population and/or global environmental problems through the development of a superior mobility system, and wants to create new services and customer values with mold-breaking technologies such as the Internet of Things and artificial intelligence Big Data.
- To this end, in 2016 JR East established a "Mobility Innovation Consortium". The objective of the consortium is to contribute to building next-generation public-transport systems and tackle difficult social challenges together with other transport operators, global/local corporations, universities, and other institutions. The consortium is open to any company owning innovative technology, services, or relevant ideas, regardless of size or experience in the railway industry
- It has currently launched three working groups:
  - Door-to-Door Services (realize seamless journey from departure to destination)
  - Smart City (value proposition of public transportation in the next-generation city)
  - Robotic technologies in public transportation

4) SNCF and FIF Digital Open Lab to accelerate go-to-market of innovative maintenance solutions

- The Digital Open Lab is a partnership between SNCF Réseau – the French rail infrastructure manager – and the FIF (The French Railway Industry Association) in order to co-develop tomorrow's solutions.
- SNCF Réseau is providing the railway companies with a testing site, the relevant entrance support, and intellectual support including specifications design, feedback, agile project management and normalization support.
- The innovation will be launched in 2018, and is planned to last three years. It will start with IOT solutions, but is likely to be later extended to other technologies such as virtual reality or robotics.

The solutions will be developed during three months of agile sprints, and include both emerging and mature solutions, as well as hardware (sensors) and software (algorithm) solutions.

5.4.3. Imperative #10: Open the system (harmonize data, open data, open collaboration platforms)

As public transport becomes increasingly digital, high-quality data will be the foundation of everything we will do in the future. Fortunately, data on transportation is becoming increasingly available. Intelligent data collection and processing can improve both transport planning and real-time operation.

There are many uses for data: Mobility-as-a-Service, contributions to smart city concepts, increased operational efficiency, traffic optimization, better service planning, predictive and condition-based maintenance, journey planners and customer-relationship management, enhanced safety and security, and management of key performance indicators in concessions[34] Overall, the combination of opportunities offered by big data and open data (the practice of providing data to third-party providers for the development of customized services) should allow the development of mobility services offerings that are better aligned with mobility demand, and can be further individualized to take account of specific travelers' needs, habits and travel patterns.

While there is general agreement on the benefits of open data, there is still plenty of ambiguity around data, and defining the right data policy is still a key challenge today:

- How is the relevant data to be treated?
- Who owns the data, and who should be authorized to access it?
- Should mobility operators provide application programming interfaces (APIs) to provide access to real-time data to third parties?
- Who should bear the costs of data collection and structuring?
- How are we to develop efficient information systems used by a critical mass, including citizens at large?
- How are we to comply with privacy and right-to-be-forgotten rules and prevent misuse of data[35]?

The pressure to find win-win data-sharing solutions (what to share, how and with whom) in order to make the most of the gold mine the industry is sitting on has never been more intense. In this context, it is important to develop a holistic digital mobility strategy that clarifies what to collect, how to process it, and what to share, how and with whom? The development of a digital mobility strategy in consultation with the transportation-organizing authorities and all mobility stakeholders (public and private) should be based on four pillars:

- Harmonization: Definition of common rules and standards to ensure comparability and to facilitate the usage of collected data. (On the technical side, various standards and formats are to be considered.)
- Identification of the relevant data to share and the establishment of standards: Sharing format, license exemption for data use and quality control.
- Approaches, policies and regulations related to the sharing of data (or open data).
- Collaboration: Strengthening of relationships between mobility stakeholders (public and private) and development of innovative approaches with companies and citizens (hackathons, living labs, open innovation). See Focus Box below on open-collaboration platforms

- Improved passenger information (planning, real-time and predictive): This can be made possible through the establishment of a real-time planning platform and applications (see imperative #11 hereafter) that are customizable in their choice of itinerary, the integration of traffic conditions and the state of the infrastructure.

5.4.4. Imperative #11: Network the system (Integrated mobility platforms and apps)

Integrated mobility platforms and applications (sometimes also called "MaaS platforms") are the digital backbone of Mobility-as-a Service that allow for the creation and management of journeys and act as interfaces between the consumer and the physical devices (infrastructure and solutions) executing the transportation. From the customer's point of view, by reducing the complexity of juggling multiple transportation modes and operators, integrated mobility platforms provide a seamless and personalized door-to-door journey, thereby significantly maximizing the quality of the customer experience.

The development of integrated mobility platforms is accelerating due to several factors:

- The imperative for cities and regions to improve the management of mobility in their territories.
- The progressive opening of operators' data.
- The development of big data, which is leading to more efficient algorithmic processing of data – in particular by artificial intelligence – and, in turn, making these platforms more and more efficient.
- The existence of a market of customers/users sensitive to digitalization and the sharing and usage economy.

MaaS platforms are being introduced all over the world, with different kinds of business models, integration levels and value propositions. (See illustration 42.)

Most MaaS platforms are not profitable today, as they are still in the ramp-up period. The set-up of a MaaS platform

Figure 41: Seamless end-to end customer journey

Source: Arthur D. Little, Qixxit

involves initial capital investments in both the platform and application development, as well as operational expenditures related to running the platform and continuously adding new functionalities. But one of the most important cost centers is the marketing and sales department devoted to the development of partnerships with cities and operators, as well as to customer acquisition, unless an incumbent operator introduces the platform with an existing customer base.

Given the costs at hand and the fact that the percentage of intermodal journeys only represents a fraction of trips made in urban centers today, the financial business case of MaaS platforms is not driven today by commission fees from aggregated mobility services. Indeed, some MaaS platforms do not even apply such fees. Commission fees from value-added services (such as retail or advertising) do not currently drive it either, as related revenues are still low (though this might change in the future when the level of adoption gets higher) and only represent a fraction of the costs.

The main driver of a positive business case for operating an MaaS platform lies in the fees paid by consumers for tailor-made mobility services. The real valorization of MaaS is actually linked to the capture of a portion of the budget currently associated with owning a car, which represents over 80 percent of the mobility budget of the typical household[36]. While most MaaS fees are currently paid on the basis of "pay as you go", as MaaS consumers progressively give up their cars, they are expected to evolve in the future toward packages with monthly subscription fees, which would mean significant revenues for MaaS operators.

But is it really the case that consumers will be willing to swap their cars for an MaaS concept? As things stand, empirical evidence of such a shift is still scarce. One relevant case study was conducted in Gothenburg (Sweden), which ran an MaaS pilot involving 70 households for six months in 2013–2014 on the Ubigo platform, based on a subscription model of 130€/month.

Figure 42: Important MaaS initiatives worldwide

	Established	Stage	Locations	Modes integrated			Depth of integration				
				Public transport[1]	Public individual transport[2]	Soft mobility[3]	Plan	Book	Pay		Value-added services
									As-you-go	Packages	
Upstream (back-end)	2016 (2014 as SMILE)	Running	Vienna, Planned in Graz (AU), Linz (AU), rest of Austria and Hamburg	■	■	■	■	■	■		
Whim by Maas Global	2016	Running	Helsinki, Planned in West Midlands (UK), Antwerp (BE) and Amsterdam (NL)	■	■	■	■	■	■	■	
UbiGo	2014	Pilot	Gothenburg (SE), Planned in Stockholm1	■	■	■	■	■	■	■	
Hannovermobil 2.0 by üstra	2014	Running	Hannover (DE)	■	■	■	■	■	■		■
moovel by Daimler	2012	Running	Several German regions, North America	■	■	■	■	■	■		
helloGo by Keolis	2017	Pilot	Utrecht (NL)	■	■	■	■	■	■		
S'hail by RTA	2017	Running	Dubaï	■	■		■	■	■		
Qixxit by Deutsche Bahn	2013	Running	Germany (urban mobility offers), Europe (Train and flight deals),	■	■		■	■	■		
Föli/Tuup	2016	Running	Turku city (FI)	■	■	■	■	■	■		■
Emma by Tam	2014	Running	Montpellier (FR)	■	■	■	■	■		■	■

Source: Arthur D. Little analysis
[1]: e.g. metro, tram, bus, train, school bus, coach, monorail ; [2]: e.g. taxi, limo, e-hail, ride-sharing, car-sharing, car rental; [3]: e.g. walking, bike-sharing, bike rental

In the after-the-fact survey[37], nearly four out of five respondents said they would be interested in becoming regular customers if the service resumed. A recent quantitative study performed for a major urban area in western Europe based on feedback from several thousand respondents confirmed that sentiment. It reported that early adopters of MaaS could represent between 5 and 10 percent of mobile individuals in the cities (mainly consisting of active citizens who had above-average income and were digital-native), and that ultimately only 20 to 30 percent of individuals would not be addressable by MaaS due to their characteristics (low level of mobility, digital averse, strong attachment to car ownership).

In addition to revenues accrued from operating the MaaS platform itself, earnings can also be gained from sales of data analytics or – for entrants with first-mover advantage – from sales or operation of MaaS platforms and applications to third parties (cities, private operators) on a "white label" principle.

While most MaaS platforms are not profitable today, there is a reasonable chance that they could make money in the future, and as only a limited number of platforms will be able to sustain themselves at city or regional level, there is a high likelihood that there will be a premium for the first entrants.

But will the gradual introduction of MaaS yield positive benefits for public transport? Results from MaaS pilots in Gothenburg (Ubigo), Vienna (Smile, now Upsteam), and Helsinki (MaaS Global) indicate higher usage of public transport by MaaS users. (Small, sample-size caveats apply.):

- Half of the respondents in after-the-fact surveys reported using public transport more often while the Ubigo service was active, and nearly half reported declines in private vehicle usage.
- Results of the SMILE pilot in Vienna in 2015 revealed that 67 percent of users were using alternative routes, 21 percent reduced their usage of private cars, 26 percent increased their use of public transport, and 47 percent used other means of transport.
- A survey of Whim users in Helsinki found that the percentage of trips made by public transport rose to 74 percent, compared to 48 percent before Whim became available.
- A recent study[38] performed in London amongst 1,500+ people confirms these trends, as it concluded that, amongst current car users, 35 percent would substitute [part of their] car usage for public transport, 17 percent for bicycle, 11 percent for taxi and ride-hailing, and a further 17 percent would walk more as part of their trips.

It is also worth mentioning that, when MaaS payments consist of monthly subscription fees based on an "all you can eat" principle, MaaS operators will have a financial incentive to favor usage of public transport and shared mobility solutions, as these have lower costs per passenger-km, implying a higher margin for the MaaS operator.

How does it technically work? Put simply, integrated mobility platforms' reference architecture is made of two main parts, connected via API to the end user and the physical devices executing the transportation:

- A back-end platform (or "middle ware"): A central B2B platform integrating the different mobility solutions (infrastructure and solutions) and data, as well as allowing for real-time treatment of information to provide the best-possible services, taking into account the end-user request and equipped with a transport interface connecting to the physical devices executing the transportation.
- A front-end application acting as a customer interface (B2C), which is in charge of proposing journeys to the users, whether single mode or combining several mobility solutions. This will be adapted to the profile and preferences of the users and allow for integrated information, booking and payment, and additional (non-mobility) services.

While technology is getting more mature and easily accessible, setting up an MaaS platform remains a considerable challenge from both a market and a business perspective. While MaaS platforms are progressively being introduced all over the world, several MaaS market evolutions scenarios and operator business models are still emergent. (See box "MaaS market evolution scenarios and business models for IMP operators".)

And so there are still risks for operators in contributing to the development of a mobility-as-a-service concept, by either taking the lead or participating in the set-up of integrated mobility platforms or applications. But it cannot be denied that MaaS presents a number of opportunities for transport operators:

- They can take advantage of the differentiation offered by MaaS to strengthen their competitive positions beyond the sole operation of transport modes.
- They can add value to the customer portfolio (loyalty program, upsell strategy through the sale of transport solutions and third-party services).
- The development of a better understanding of mobility flows and expressed mobility needs will increase the addressable market and allow for an improved coverage rate. This holds especially true for new mobility solutions

providers for which customer acquisition costs can constitute a barrier to growth.

- International operators can take advantage of market opportunities associated with MaaS during calls for tenders or in the course of negotiating contracts with PTAs. The development of an MaaS platform may increasingly become a "standard" demand from PTAs in the coming years in the context of the development of sustainable transport policies, thus enabling the best-positioned operators to differentiate themselves through MaaS.

Failure to develop – as leader or as partners – a MaaS offering may also entail risks for transport operators.

- Direct risk of losing part of the revenue from the sale of tickets (which constitutes part of the endowment for the incumbent public-transport operators).
- Long-term risk of undermining the core business and the competitive advantages of direct contact with the customer.
- Finally, there will be an opportunity cost in not capturing the potential of the MaaS market released by the transition from mobility ownership to mobility usage.

Mobility solutions providers (operators or over-the-top players) and public-transport authorities wanting to engage in the development of a MaaS platform should consider the following key success factors[39]:

- Take the time to define the most fitting industrial and partnership model, taking on board the city or region specifics to make sure all stakeholders that will have important roles to play in the success of the MaaS platform (including public transport authorities and third-party providers) can be easily involved, now or in the future. Several industrial and partnership models can be considered – including JVs between multiple entities – the most appropriate of which will be driven by existing regulations and allocation of duties, asset ownership, access to customers and availability of skills.
- Start small but move fast. While comprehensiveness is key when it comes to the inclusion of available transport modes and functionalities, it is advisable to start with a limited set of transport modes and functionalities and extend it gradually. This approach enables high agility in reacting to new market developments and makes an early launch more feasible. It also reduces the implementation risks of a "big bang" approach, which – in a worst-case scenario – could mean ending up with an outdated system after a costly implementation process extended over several years.
- Keep it simple and compelling for the consumer. The first point of contact of a user is the application. A lean, stable, and compelling interface with all relevant functionalities is required to catch and maintain customer interest. To gain user-acceptance quickly, the processes confronted by the customer should be as simple as possible. Best practice shows that a lean booking-and-payment process is not more than four to six clicks. Also, consider an agile software development approach to help react to user requests, make changes in preferences and keep the solution up to date.
- Use advantages by personalization. Offering a wide range of functionalities and transport modes also bears the risk of creating a system more complex than most users require. Customer preferences differ from one person to another; a high degree of personalization means a customer can select the optimal transport modes and functionalities to enable a superior personal experience.

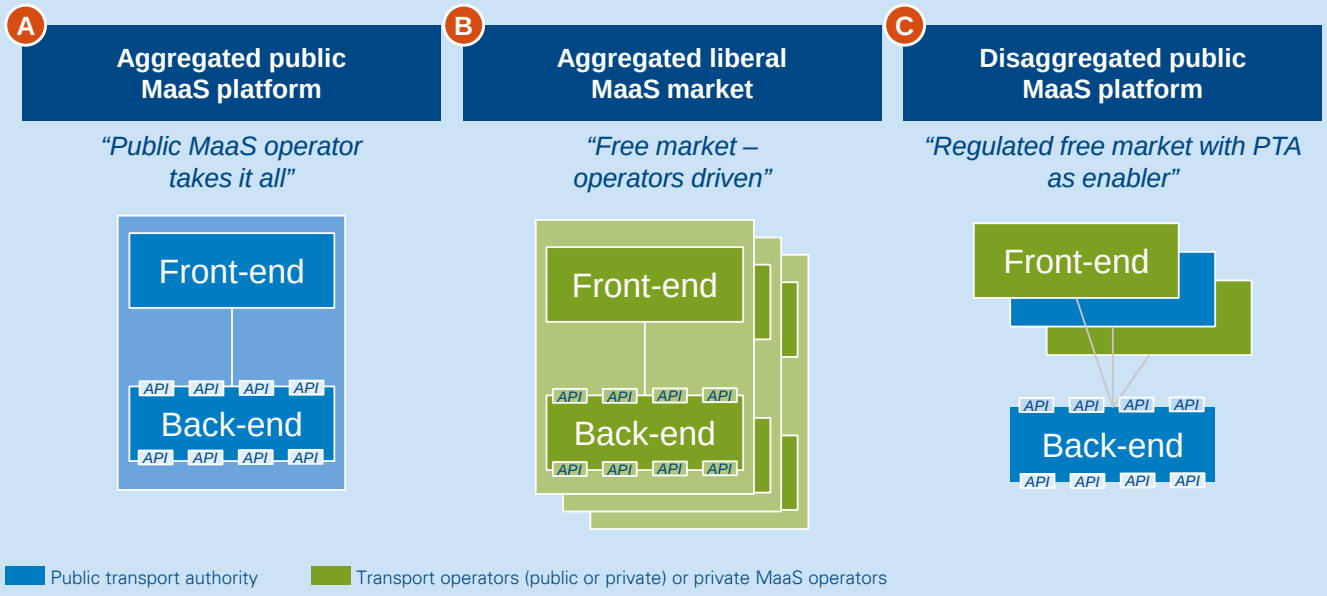
MaaS market evolution scenarios and business models for IMP operators

While a variety of MaaS platforms are being introduced all over the world, MaaS market evolution scenarios and operator business models are still emergent.

From a market perspective, one can distinguish **three evolution scenarios at city or regional level**. The key differentiators between them are the opening up (or not) of public-transport data and APIs toward third parties, the development (or not) of a back-end B2B platform by the public authority, and the level of openness of that back-end platform for third-party, front-end applications.

- The "aggregated public MaaS platform" market scenario is a fully public system in which public-transport data and APIs are not open to third parties, and in which a public player (generally the PTA) develops and operates a unique MaaS platform and front-end application, integrating its own public-transport mode and aggregating (or not) private modes of transportation under its own conditions. This scenario has been the one chosen so far by cities such as Dubai, Hannover and Karlsruhe. It bears the risk of not being able to realize a comprehensive MaaS concept if most private modes are not aggregated, and does not allow for free-market dynamics.
- The "aggregated liberal MaaS" market scenario is a fully liberal scenario in which public-transport data and APIs are fully open to third parties and several aggregated platforms and apps (closed to third parties' B2C apps) are competing with each other, integrating and aggregating public- and private-transport modes. The advantage of this scenario, currently in place in Helsinki and Utrecht, is that it allows free-market dynamics to play out for the benefit of the consumers. It would, however, require strong governance by the PTA to ensure that private MaaS operators are striving for the system optimum. This market scenario is advocated by MaaS Alliance, a public-private partnership (with members such as MaaS Global, Xerox, Uber and the Minister of Mobility of Helsinki) whose main goal is to facilitate a single, open market and full deployment of MaaS services[40].
- The "disaggregated public MaaS platform" market scenario is an interesting one as it could be seen as combining the best of both worlds. In this scenario, in which public-transport APIs are closed to third parties, a public actor (often the PTA in collaboration with the PTO) develops an MaaS B2B platform that is open to third parties, thereby allowing several front-end apps to compete in the market, with the possibility of aggregating

Figure 43: MaaS evolution scenarios



Source: Arthur D. Little

Figure 44: MaaS – market evolution scenarios

	Aggregated public MaaS platform "Public MaaS operator takes it all"	Aggregated liberal MaaS "Free market – Operator(s) driven	Disaggregated public MaaS platform "Public authority enabler"
Characteristics & requirements	■ Public actor (generally PTA) develops and operates a unique MaaS platform and app ■ PT data and APIs closed to third parties ■ Aggregated platform and app (closed to third parties' B2C apps) ■ Integration of public transport and aggregation (or not) of private modes	■ Free market: Several aggregated platforms and apps (closed to third parties' B2C apps) are competing, integrating and aggregating public and private transport modes ■ PT data and APIs open to third parties ■ Roaming ecosytem	■ Public actor (often PTA in cooperation with PTO) develops a MaaS B2B platform ■ PT data and APIs closed to third parties ■ Disaggregated platform open to third party (against a fee) ■ Several front-end apps can compete with public and private transport modes
Advantages	■ Simplicity: access to multiple (public) modes of transportation through one single app ■ Public mastery of public transport sales channels (no risk of disintermediation by private players)	■ Free-market dynamics fostering development of new mobility solutions and price competitiveness ■ Ability to realize comprehensive MaaS concepts, as all transport modes can be integrated	■ Abilty of PTA to set strong governance to guarantee system optimum ■ Free-market dynamics fostering development of new mobility solutions and price competitiveness ■ Ability to realize comprehensive MaaS concepts (all transport modes)
Disadvantages	■ Inability to realize comprehensive MaaS concept in case most private modes are not aggregated ■ Development and operating cost borne by PTA – risk to become outdated ■ Stronger competition from suppliers; less cooperation and co-development	■ Risk of loss of mastery of public transport flow by public – Strong PTA governance required to ensure system-level optimum ■ Risk of private monopolistic situation if one private player takes it all ■ Risk of disintermediation for operators that do not have their MaaS platforms	■ Development and operating cost borne by public, requiring sufficiant funding over time to secure development of back-end ■ Risk to become outdate, however more limited than with aggregated pulibc MaaS platform
Examples	■ Moovel Transit by KW (Karlsruhe) ■ S'Hail by RTA (Dubaï) ■ HannoverMobil by Ustra (Hannover)	■ Whim by Maas Global (Helsinki, Antwerpen) ■ HelloGo / Keolis (Utrecht)	■ Upstream B2B platform (Vienna, Graz, Hambiurg) ■ Gothenburg (Ubigo)

Source: Arthur D. Little

all public- and private-transport modes. The advantage of this scenario, currently in place in Vienna (Upstream, WienMobil), Graz (GrazMobil), Linz (LinzMobil) and Gothenburg (UBIGO), is that it allows market dynamics free rein while providing transport authorities with the ability to set up the appropriate governance to ensure MaaS operators strive for the system optimum. It however requires public funding for development and maintenance of the back-end.

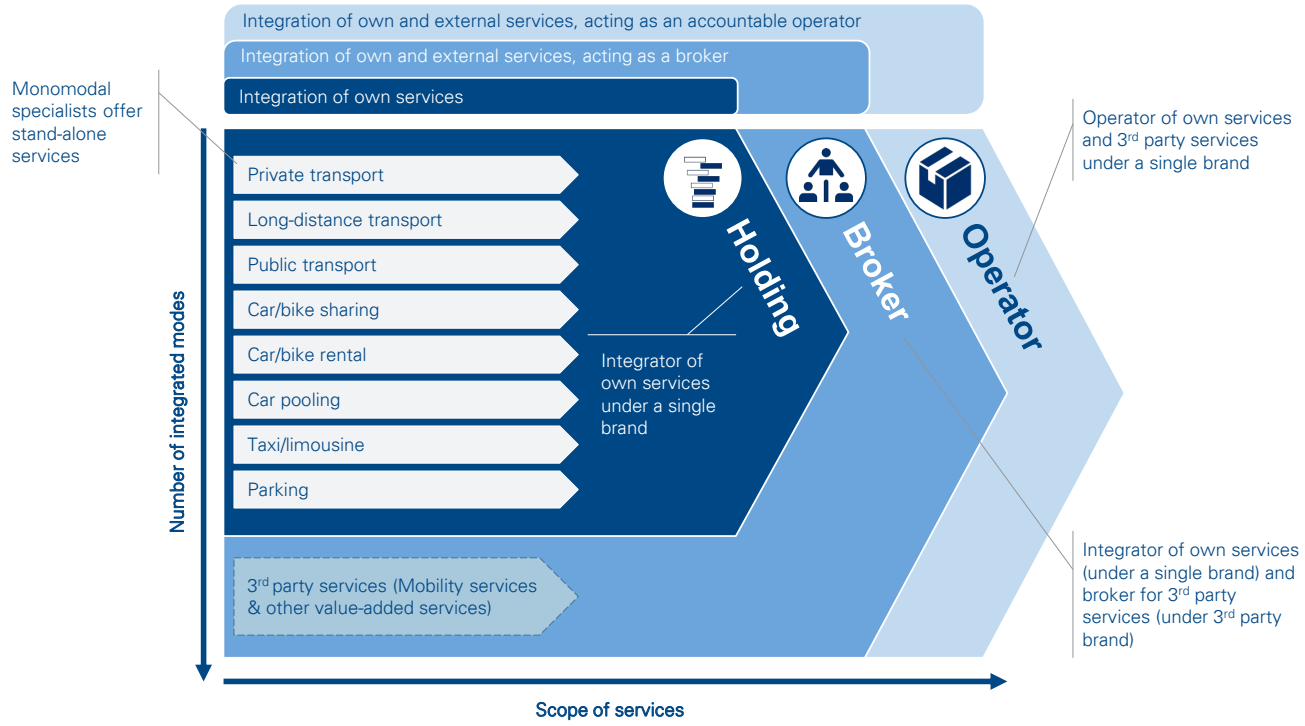
Independent from the MaaS market scenarios, one can distinguish three business models for operators of integrated mobility platforms:

- The "holding" model: A "holding" player integrates own modes of transport on one platform, while third-party modes must be accessed separately through proprietary apps (if available). In essence, this model does not allow for the realization of the Mobility-as-a-Service concept, as the number of modes accessible are limited. Examples of integrating players include rail companies that provide long- as well as short-distance transport and traffic authorities operating several public-transport modes.
- The "broker" model: An integrator of own transport modes (under a single brand) and a broker for third-party services (under a third-party brand). On the mobility platform, there is no distinction between their own and foreign modes, as the user is offered all services in one place. However, whereas tickets may be consolidated for own transport modes, separate tickets need to be issued for third-party services. This opens up the possibility of also participating in third-party ticket sales via the platform (margin) or benefiting from partner fees. The "aggregator-broker" can also apply to over-the-top aggregators that do not have proprietary assets but only aggregate and commission the service of mono-modal specialists. Most MaaS front-end operators currently follow that approach, including Moovel, Qixxit, and WienMobil.
- The "operator" model: An integrator of own transport modes (when available) and third-party services under a single brand. Users may buy one ticket for each trip that

covers all relevant segments of the journey. To do so, the operator acts as an intermediary and forwards a share of the ticket fees from the users to the relevant third-party providers (subcontractors). As much as this model offers greater convenience and a better customer experience, it also creates exposure to third-party obligations and liabilities for the MaaS operator in situations in which third-party services do not deliver as promised. This operator model is the current paradigm of MaaS Global.

The decision over which business model should be pursued reflects the level of complexity and risk that the Integrated mobility platform (IMP) operator is willing to manage, and has an effect on which functionalities along the customer journey the platform can provide to end users. We reckon that the "holding" model is likely to gradually disappear and be aggregated by other players. Given the high liability risk of offering third-party services under own accountability and the slight effect on the customer experience, we expect the "broker" model to remain the main model in the coming years, and to be gradually replaced by the "operator" model as the MaaS concept stabilizes.

Figure 45: Integrated mobility platform business models

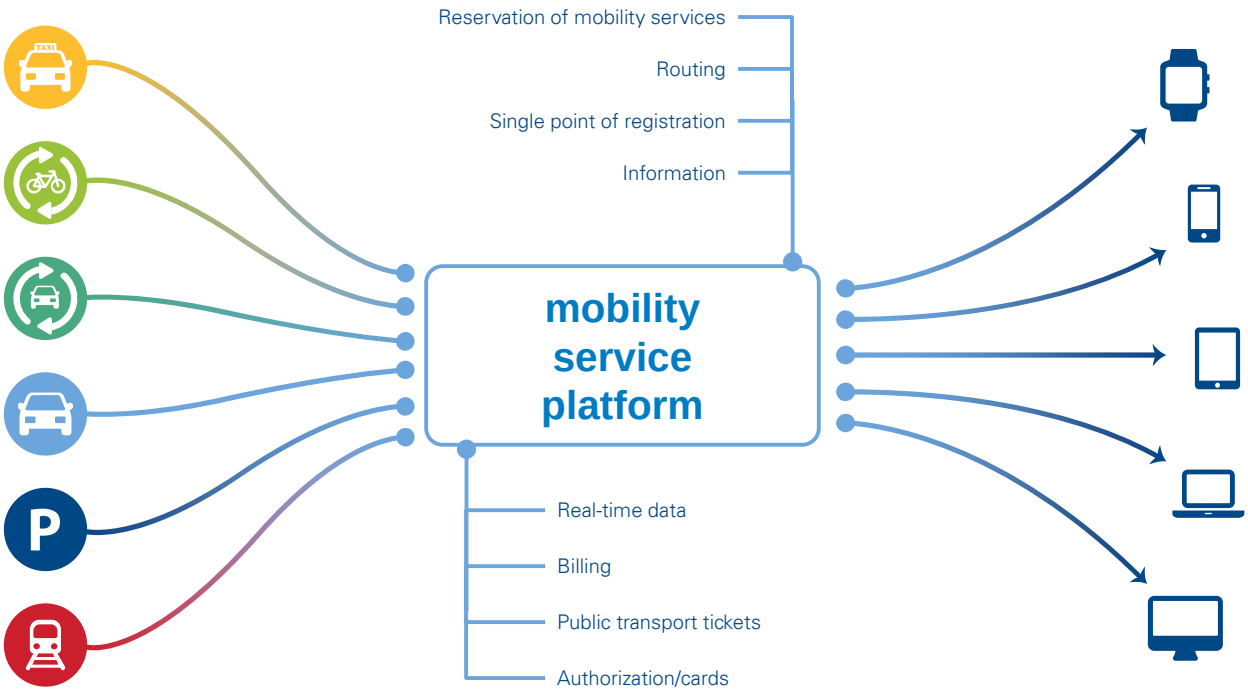


Source: Arthur D. Little

Case Study: Upstream as an enabler for Mobility-as-a-Service in Vienna and beyond

Upstream illustrates model 3: the "disaggregated public MaaS model". The prototype of a mobility service platform in Vienna was developed by the SMILE research project to provide mobility services in the areas of integrated information, booking and payment. The result of this was the foundation of Upstream – next level mobility GmbH in early 2016 as a subsidiary of Neue Urbane Mobilität Wien GmbH (NeuMo) and Wiener Linien GmbH & Co KG in the Wiener Stadtwerke group.

In this regard, the platform forms the basis for customizable applications and tailor-made functions. These are offered to public (often municipal) mobility service providers, as well as private organizations which then integrate them as upgraded services to their customers. This way, they are able to provide centralized, one-stop infrastructure for a multitude of related services in the area of mobility – from information, registration, reservations and ticketing to fleet management and individual mobility options. As a result,



As a public-service platform provider, Upstream – next level mobility GmbH crosslinks all digital mobility services (public transport, taxis, car-sharing, bike-sharing, garages, charging stations, etc.) on one back-end platform. The main purpose is to ensure mobility for the people, regardless of their income or social status. Therefore, the public open-service platform is the backbone which allows the public-transport operators to offer a broad range of mobility services, reduce development efforts for private third-party mobility offerings (with easy access to the customer), and still be in the driving seat for further innovation by securing the own market position and holding customer and mobility-usage data throughout the city.

positive and sustainable changes in mobility patterns can be initiated, which also encourage the development of different business models and innovations. All associated services can be expanded as interfaces as desired. The basis is always the mobility service platform.

Furthermore, the platform provides an opportunity to develop private third-party business models, products, support, and easy customer access. Apart from this, the digital infrastructure enables innovation and research in the area of digital mobility.

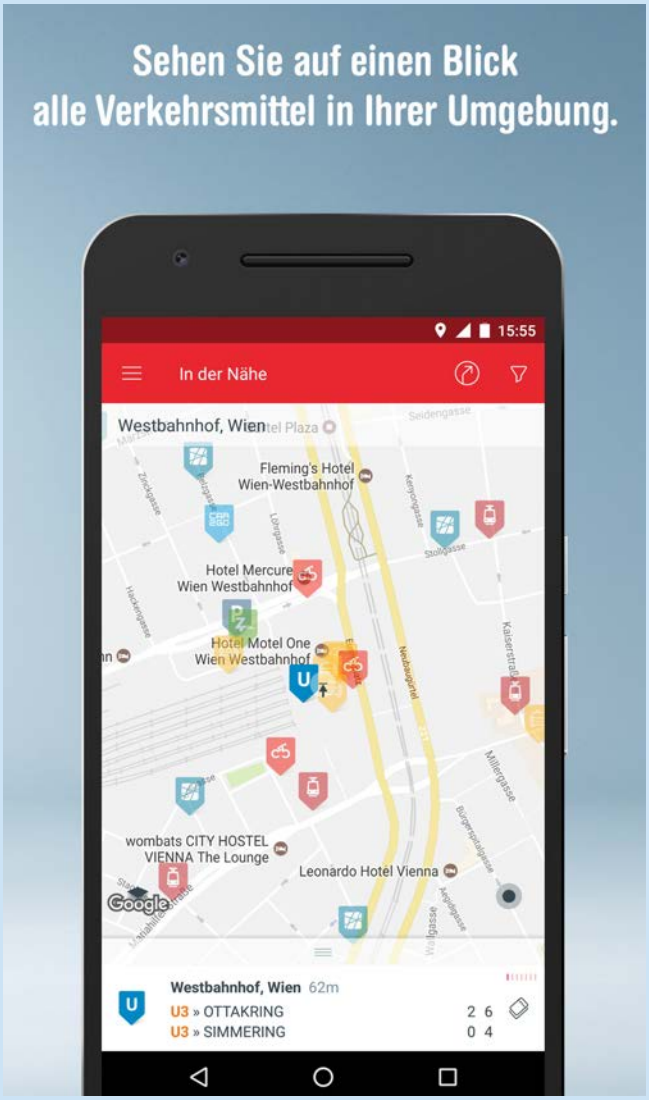
Upstream provides this digital infrastructure and therefore ensures innovation generation such as:

- Central hub for mobility real-time data.
- Enabling on-demand mobility by providing digital-basis infrastructure.
- Availability of a central platform with access to all mobility services for future developments in traffic control and autonomous driving.
- Information and detailed analysis of traffic flows.

Products and Services running on the Upstream platform:

1) PTA multimodal App – WienMobil

A central digital access point to mobility



In addition to its platform, Upstream developed a multimodal iOS and Android App WienMobil/CityMobil. The app has run live in Vienna as WienMobil since June 2017, after a one-year probing phase with WienMobil Lab. In May 2018 a new version of WienMobil will be launched in Vienna, taking into account a completely revised user-experience concept. Following this launch, WienMobil will be implemented in Graz (GrazMobil), Linz (LinzMobil), and other major cities in Austria.

2) JÖ App for company mobility management

JÖ combines all publicly accessible mobility offers with the company's own fleet of vehicles. Staff can see at a glance which form of transport is currently available and, at the same time, the fastest, most efficient and optimum CO_2-saving for the particular service route. The desired modality can be reserved and invoiced with one click. JÖ can also be used for private purposes.

3) Interface access – the basis for the establishment of innovative business models

Access to the Mobility Service Platform (MSP) interface opens up a wide variety of urban mobility offers. Different services and functionalities can be combined individually, and that way enable the creation of unique, innovative business models, such as a big tourist application in Vienna using the interfaces of the Upstream Mobility Service Slatform or a planned test application of MaaS Global and Upstream, further combining front-end business models with the digital infrastructure of Upstream – next level mobility GmbH.

4) Digital mobility solutions for individual requirements

In association with customers – public and private organizations – Upstream devises mobility concepts geared to individual requirements and provides the necessary services, functions and applications. Upstream contributes know-how and a unique network to joint implementation projects. Among these are projects with big city development areas, in which mobility within the housing area plays a major role and access needs to be easy and smoothly connected with other publicly accessible transport options within the city.

International cooperations:

Besides the national co-operations with all major cities in Austria, Upstream aims to serve as an enabler in the international context for the creation of similar models with publicly owned digital infrastructure, providing know-how and technology with full access to the source code.

In co-operation with the PTA/PTO of Hamburg, Hamburger Hochbahn AG Upstream develops the mobility service back-end platform for Hamburg and hands over the platform step-by-step as digital infrastructure to Hamburger Hochbahn AG, enabling Hamburg to run digital infrastructure to enable MaaS in the city. In October 2017, Transport Systems Catapult (UK) also entered into an agreement with Upstream to benefit from the experience, know-how and technology gained in Vienna to enable MaaS in the UK. Moreover, several proof-of-concept projects have been performed in 2017 together with PT partners in Europe.

Data science

In 2017, Upstream started to run a data science unit producing data analysis, visualizations and individual reports on traffic flows in Vienna. This allows it to, on the one hand, use analysis to improve public-transport services according to users' needs and, on the other hand, forms an important basis for the management of autonomous transport systems in the future. Additionally, private companies and organizations can benefit from the analysis of the traffic-flow data collected and evaluated at Upstream.

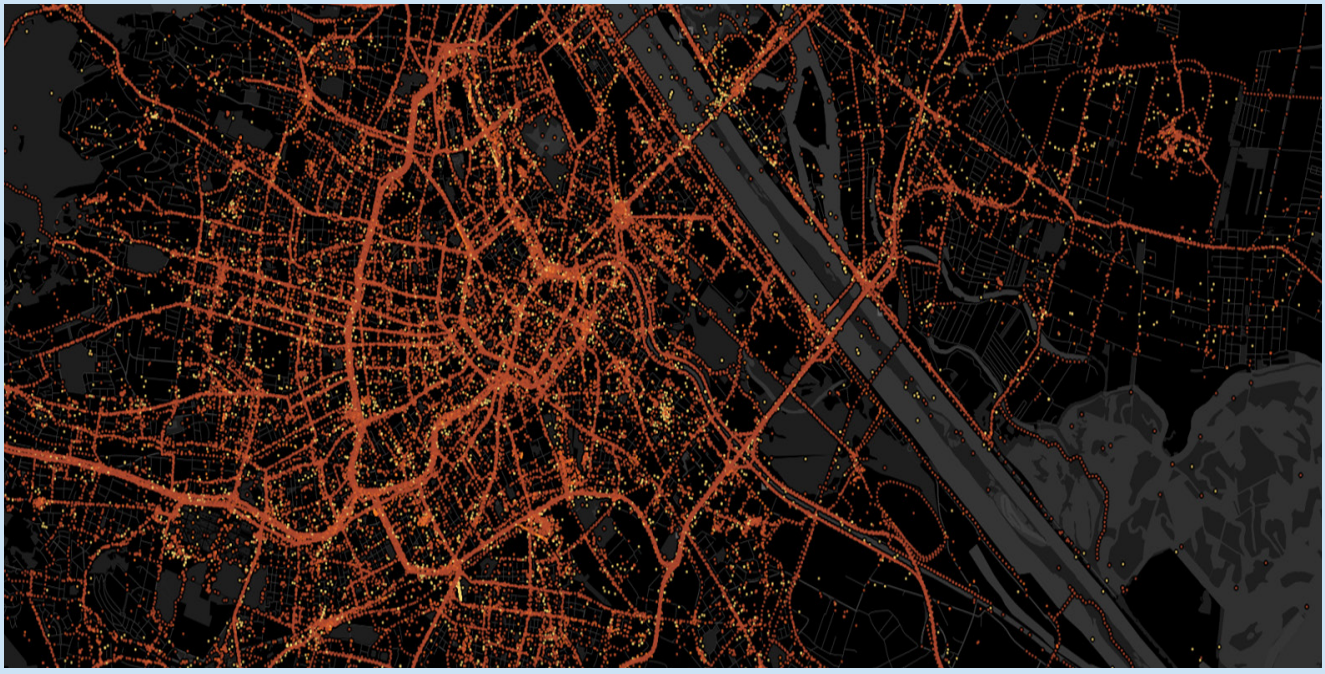
Facts about the company

Current number of employees: 30, reaching roughly 50 by the end of 2018, with major growth in the field of development skills.

Company organization: The company is split into four business units, which are:

- Business: Account/project Management, data science, sales, delivery.
- Development and Operations: Development, technical operations of the platform, technology scouting, delivery.
- Research and Development: performing R&D projects and scouting future trends.
- Services: General services for the company (legal, office management, IT service management, etc.).

Business case: The business case of Upstream, established in 2016, is based on the products and services mentioned above, and the company aims to be self-sustaining by 2020. Additional revenue streams from international collaboration and data science allowed for a positive business case earlier than expected.



5.5. Dimension 5: Successfully manage transformation

5.5.1. Introduction

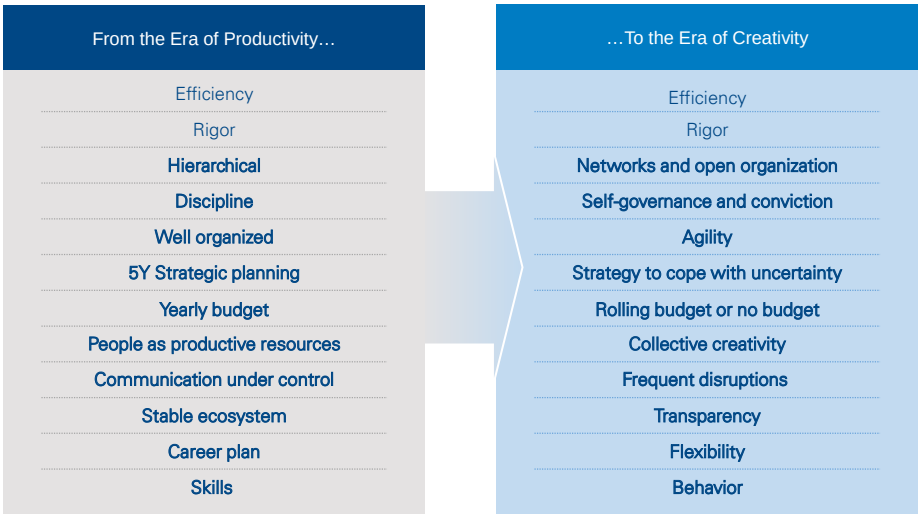
As mentioned earlier on this report, transformation is all the rage within mobility ecosystems these days, as established businesses are at constant risk from ambitious upstarts, many of which are centered on disruptive business models built on digital technology. Much has been written about how these market entrants create an urgent need for existing operators to adapt their visions, strategies, business models, organizational structures and capabilities to the new reality in order to sustain their competitive advantage. Much has also been written about the need for new mobility solutions providers, in turn, to continuously reinvent themselves to keep pace with technological advances and avoid being overtaken by the next disruption.

But in an evolving mobility ecosystem, reinvention in and of itself is not enough. A visionary strategy will only succeed if it is implemented in a sufficiently agile way to remain competitive in the short term and relevant in the long term.

Successfully managing transformation implies a change of paradigm for mobility operators, which must embark on journeys from the "era of productivity" to the "era of creativity". This change of paradigm implies many changes for companies:

- Moving from a situation of hierarchy, discipline and rigid organizational structure, with clearly defined roles and responsibilities, towards a networked organization and open innovation, involving an extended network of internal and external stakeholders, self-governance driven by conviction, and agility in processes and decision-making.
- Moving move from a context in which businesses remain mostly stable over time, driven by five-year strategic plans and yearly budgets, towards one in which companies have to constantly adapt (evolving strategy in an uncertain environment in which scenario planning becomes key) and be able to deliver effective change in months rather than years, via rolling budgets rather than monthly budgets.
- Moving from a situation in which staff were considered solely a productive resource towards a culture that requires companies to give meaning to staff, in which values and behavior are considered as important as skills sets (which must evolve continuously), in which staff are considered active change actors, and in which collective creativity and open innovation are considered the norm to drive change and accommodate disruption in a structured way.
- To move to a situation in which the ability to be customer-centric, to quickly understand evolving customer needs and to learn faster than your competitor are vital weapons in the battle to find smart ways and solutions to fulfill those needs. Indeed, these may constitute one of the main drivers of competitive advantage.

Figure 46: Embarking on the journey from the past to the new world



Source: Arthur D. Little

5.5.2. Imperative #12: WHY transformation

The reason organizational transformation is so complex is down to the need for businesses to address simultaneously three key questions:

- What are the major disruptions that are likely to impact the mobility industry, and what strategic responses are needed?
- How can the envisioned strategic responses be turned into rapid, practical actions to effectively drive change?
- How are companies to combine the ability of management and the organization to deliver lean "day-to-day" operations, while at the same time ensuring the right mechanisms are in place to think "outside the box" in order to continuously identify the next breakthrough solutions that will allow them to sustain and build competitive advantages?

We believe we should hold back from the argument for total transformation. Instead, what is critical to building lasting differentiation and competitive advantage is to carry out the required adaptations while, at the same time, preserving, enhancing and expanding the core business.

Reaching this point involves overcoming two issues:

- Firstly, the business-operating model needs to be adapted to match the speed and scale of new mobility solutions players (or, in the case of new mobility solutions providers, to maintain their speed and scale).
- Secondly, organizations have to transform their legacy business models and operations, making their value chains as lean and agile as possible.

To do this they need to adopt some of the methods of new players. That is, they need to collaborate, both externally and internally; they need to center on customers; they need to become more agile; they need to focus on data; and they need to embrace a culture of continuous experimentation.

Several of the required capabilities for companies to perform in this "new normal" can be achieved through leveraging and managing extended ecosystems: ecosystems are the new competitive landscape where companies need to play, and leveraging ecosystems allows building and developing capabilities much faster, with limited investments and risks.

However, while several capabilities can be sourced and developed through leveraging ecosystems (and developing capabilities to manage ecosystems), our experience suggests that successful transformation will depend on addressing four critical elements internally. These are leadership, culture, organizational structures, and governance, and talent management.

- Leadership: Ensuring a company-wide transformation requires strong leadership and clear communication from top management to drive the right mind-set and behavior of staff at all levels of the organization towards the required change. Strong and robust leadership is also required to ensure that the right decisions are taken in terms of focus and investment, and shared throughout the organization to avoid dispersion of efforts.
- Culture: An organization seeking to become more agile needs to overhaul its corporate culture. Traditional companies generally have cultures that hinder rather than help transformation, because new approaches are held up by established ways of working and thinking within the organization. The company culture needs to be challenged in order to foster transformation. This can be facilitated through the definition of a clear sense of purpose (or "reason to exist") and reviewing existing value sets within the organization, and activating them to drive through the appropriate attitudes across all functions.
  (See Dimension 1: "Sense of purpose".)
- Organization and governance: Existing organizational cultures often have to be challenged to enable and accelerate transformation and continuous improvement. This involves breaking down legacy functional silos with a view to creating cross-functional collaboration with processes – such as new product and service development and experimentation – that flow seamlessly across departments, as well as setting up flexible structures to manage collaboration and open innovation with external stakeholders. Governance mechanisms will often need to be challenged as well, particularly in terms of delegation of power, in order to speed up decision-making.
- Talent management: Companies seeking to develop the capabilities that will enable them to become more agile need to move away from only hiring people based on current specific skills, towards acquiring people with the right set of values, mind-set and behavior and the ability to learn continuously to develop the new skills required in an evolving environment, including functional competencies around digital technologies and processes.

Finally, successful transformation will be driven by the ability of organizations to develop the capabilities and energy to become "viable systems" that are able to adapt continuously to the changes that are occurring in their ecosystem, with minimal effort and while remaining true to their "sense of purpose" and value sets.

Arthur D Little

Arthur D. Little Urban Mobility Index 3.0

Arthur D. Little Urban Mobility Index 3.0

Urban Mobility Index 3.0 is more comprehensive than the 2.0 version published in January 2014. Arthur D. Little's researchers worked on seven geographical areas across six continents, with 100 cities scrutinized – 16 more than for the last edition.

Figure 47: Urban Mobility Index by regions and cities

	Americas 24		Europe, Middle East & Africa 41		Asia-Pacific 35	
"Mega-cities"– cluster of C40 Cities Climate Leadership Group 62	**US/Canada** Boston Chicago Houston Los Angeles Montreal New York Philadelphia San Francisco Toronto Washington D.C.	**Latin America** Bogota Buenos Aires Caracas Curitiba Lima Mexico City Rio de Janeiro Salvador Santiago de Chile Sao Paulo	**Europe** Athens Barcelona Berlin London Madrid Milan Moscow Paris Rome Warsaw	**MEA** Accra Addis Ababa Amman Cape Town Cairo Dubai Johannesburg Lagos	**Asia** Bangalore Bangkok Chengdu Chennai Delhi Dhaka Guangzhou Hanoi Ho Chi Minh Hong Kong Istanbul Jaipur Jakarta Karachi Kolkata Kuala Lumpur Mumbai Nanjing Seoul Shenzhen Tokyo Wuhan	**Pacific** Melbourne Sydney
World's largest cities determined by GDP share[1)] 21	**US/Canada** Atlanta Dallas Miami		**Europe** Lisbon St. Petersburg	**MEA** Baghdad Kinshasa Riyadh Tehran	**Asia** Ankara Beijing Chongqing Hyderabad Lahore Manila Osaka Shanghai Shenyang Singapore Tianjin Xi'an	
Smaller innovator cities 17	**US/Canada** Portland		**Europe** Amsterdam Brussels Copenhagen Frankfurt Hanover Helsinki Lausanne Munich Nantes Prague Stockholm Stuttgart Tallinn Turin Vienna Zurich			

Source: Arthur D. Little Urban Mobility Index 3.0; Note: 1) not included into group 1 (C40 Megacities)

The first group of cities comprises the "Megacities" cluster of the C40 Cities Climate Leadership Group (based on its membership in 2016), which consists of 62 cities committed to increasing their sustainability levels and to tackling climate change. The next group is made up of the world's largest cities, as measured by population and regional GDP share, that are not C40 members. It totals 21 cities, including seven Chinese cities, four in the Middle East and Africa, and three in the US. Members of the third group are all good-practice, smaller cities that can serve as role models for megacities. It contains the US city of Portland as well as 16 cities across Europe. According to the regional split, the EMEA region (Europe, the Middle East & Africa) dominates the index with 41 cities out of 100, followed by Asia-Pacific with 35 cities, and finally, 24 cities from both American continents.

The number of indicators surveyed has also increased. One hundred cities in the Urban Mobility Index 3.0 were assessed on the basis of 27 indicators split into three even groups, with nine indicators in each.

The first group of indicators measures **maturity of urban mobility systems**, taking into account the share of sustainable modes of transport in the modal split, such as walking and cycling, financial attractiveness and frequency of public transport, density of roads and cycle paths, and initiatives taken by the public sector to improve passenger and goods mobility. The maximum number of points a city can be awarded for the maturity of its mobility system is 36.

For this third edition of the Urban Mobility Index, we added a new group of indicators reflecting **innovativeness of mobility systems**. Parameters measured include bike- and car-sharing penetration levels, peer-to-peer sharing schemes, ride sharing and e-hail services, mobility-as-a-service platforms, and initiatives related to smart mobility and autonomous driving

Figure 48: Arthur D. Little Urban Mobility Index 3.0 assessment criteria

Maturity [max. 36 points]		Innovation [max. 24 points]		Performance [max. 40 points]	
Criteria	Weight	Criteria	Weight	Criteria	Weight
1. Financial attractiveness of PT	4	1. Mobility smart cards penetration	4	1. Transport-related CO_2 emissions	4
2. Share of PT in modal split	6	2. Mobility platforms	2	2. NO_2 concentration	4
3. Share of zero-emission modes	6	3. Bike-sharing performance	4	3. PM_{10} concentration	4
4. Road density	4	4. Car-sharing performance (B2C)	4	4. $PM_{2.5}$ concentration	4
5. Cycle-path network density	4	5. P2P car-sharing platforms	2	5. Traffic-related fatalities	4
6. Urban agglomeration density	4	6. E-hail services and taxi platforms	2	6. Increase share of PT in modal split	6
7. Public-transport frequency	4	7. Ride-sharing platforms	2	7. Increase share zero-emission modes	6
8. Urban mobility initiatives*	2	8. Self-driving vehicles initiatives	2	8. Mean travel time to work	4
9. Urban logistics initiatives*	2	9. Other smart mobility initiatives	2	9. Motorization level	4

Source: Arthur D. Little Mobility Index
Notes : The maximum of 100 points is defined by any city in the sample for each criteria; * Initiatives of public sector

vehicles. A city can receive a maximum of 24 points for its mobility innovation level.

The third group of indicators deals with **performance of mobility systems** and answers the question: how effectively and efficiently can urban mobility systems fulfill their goals? Here we measure, among other things, air quality in terms of NO2, PM2.5 and PM10 concentration, transport-related CO_2 emissions, motorization and fatality levels, and the mean travel time to work. In total, a city can earn 40 points for the performance level of its mobility system.

As the table above shows, not all criteria have been weighted equally, a decision based on our desire to avoid penalizing cities unfairly. For example, we decided to decrease the weight of some innovativeness indicators, such as integrated mobility platforms, e-hail, ride sharing, peer-2-peer car sharing, smart mobility and autonomous vehicle initiatives, as these emerging options are highly dynamic. A city that was performing below average in 2017 in terms of digital services could improve considerably in as little as 12 months – something we established by building historic data rows. However, as the innovation group of indicators clearly shows, it is not enough to have an "ideal" modal split and cutting-edge motorization to achieve a best-in-class mobility system in the 21st century. Cities should also develop and pilot emerging physical and digital services in order to profit from upcoming quantum leaps in mobility. With regard to public-sector initiatives in urban mobility and logistics, these were weighted with two points each, as both indicators are complementary and each describes the quality of a transportation strategy and its implementation. In line with our previous urban mobility indexes, modal split-related criteria have been weighted higher as they give a reliable guide to the integral characteristics of the whole mobility system.

We take the view that, taken together, 27 indicators give a comprehensive and representative view of the mobility system of a city by covering its accessibility, affordability, safety, sustainability, innovativeness, quality and convenience. The main constraint governing the exclusion of other indicators was data availability. For Arthur D. Little's Urban Mobility Index, which is global by its nature, the data for each indicator should be available for any city in the world considered. Some indicators that were initially planned for consideration were excluded later due to the scarcity of the relevant statistical data, particularly when it came to African and South-Eastern Asian countries.

We followed a very comprehensive process to collect the data used to build the index. The first step was to initiate desk research by Arthur D. Little teams working on different continents to update the data used to compile the Urban Mobility Index 2.0 and gather new data for the indicators that had been added. In a second stage, Arthur D. Little researchers approached key contacts within public transport authorities and operators in most cities, with an offer to review their particular data and provide updates if applicable. A substantial percentage of these individuals reacted positively. Once this research was completed, all the data was consolidated and reviewed to ensure overall consistency, and some additional interactions were undertaken with selected cities as appropriate. Most data was collected in the second semester of 2017. We would like to thank to all the cities that responded to our survey, thereby radically improving the quality and robustness of data used to build the index.

Figure 49: Arthur D. Little Urban Mobility Index 3.0 – definition of assessment criteria

Arthur D. Little Urban Mobility Index 3.0 – Assessment criteria			
Maturity (max. 36 points)			
	Criteria	**Weight**	**Definition**
1	Financial attractiveness of public transport	4	■ Ratio between the priceof a 5 km journey with private means of transport and the price of a 5 km journey with public transport within the agglomeration area ■ Private means of transport car or motorcycle, depending on what vehicle type dominates in modal split ■ Cost of journey with motorized individual transport: fuel cost only, based on fuel consumption and fuel price including taxes, average of gasoline and diesel cost taken ■ Cost of public transport journey: ticket cost for a 5 km distance trip
2	Share of public transport in modal split	6	■ Percentage of the total number of person trips which are made with public transport in the last available measurement ■ Only formal public transport is considered. Informal public transport (paratransit) is considered as a part of motorized individual transport ■ Modal split definition: trips made by residents of the urban agglomeration, both motorized and non-motorized trips; trips for all purposes; trips on both working days and weekends
3	Share of zero-emission in modal split	6	■ Percentage of the total number of person trips which are made by bicycle and walking in the last available measurement ■ For cities with emerging mobiliy systems and a very high share of non-motorized transport, the modal split data was corrected in order not to suggest a high maturity level of a mobility system
4	Road density	4	■ Ratio between the total road length in an urban agglomeration and the urbanized surface area ■ Total road length definition: all roads open to public traffic (both paved and non-paved) incl. motorway network and excl. farmland, forest and private roads located within the urban agglomeration borders ■ Measured as a deviation from an optimum value. Optimum value for road density according to Fei (2011) is: average for core city 11.0 km/km², average for suburbs 3.7 km/km², average for mixed territories 7.35 km/km²
5	Cycle-path network density	4	■ Ratio between the total length of cycle lanes and cycle paths in an urban agglomeration and the urbanized surface area of this urban agglomeration ■ Cycle lane: A lane marked on a road with a cycle symbol, which can be used by cyclists only ■ Cycle path: An off-road path for cycling incl. exclusive cycle paths (for cyclists only), shared-use paths (for both cyclists and pedestrians), and separated paths (where section for cyclists' use is separated from the pedestrians' section)
6	Urban agglomeration density	4	■ Ratio between the population of an urban agglomeration and its urbanized surface area ■ Urban agglomerations taken as defined by the United Nations in World Urbanization Prospects ■ Urbanized surface area doesn't include sea, lakes, waterways, woods, forests, etc., and refers to the built-up land surface only
7	Public transport frequency	4	■ Frequency of the busiest public transport line in an urban agglomeration ■ Frequency of the busiest metro line taken; if metro not available – then frequency of the busiest bus line considered
8	Initiatives of public sector in passenger mobility	2	■ Qualitative evaluation of strategy and actions of public sector with regard to urban passenger mobility along 5 dimensions: General sustainability and restrictions; alternative engines; multimodality; infrastructure; incentives
9	Initiatives of public sector in goods mobility (urban logistics)	2	■ Qualitative evaluation of strategy and actions of public sector with regard to urban goods mobility along 2 dimensions: "Classical" measures to improve urban delivery of goods (promotion of low-emission zones for freight, time-window policy, urban distribution centers, etc.); piloting of innovative concepts and means of transport for last mile
Innovation (max. 24 points)			
	Criteria	**Weight**	**Definition**
10	Smart card penetration	4	■ Ratio between the total number of transit smart cards in circulation in an urban agglomeration area and the population of this area ■ Cards are only considered if they are issued and/or accepted by public-transport authorities or public-transport operators
11	Availability of Mobility-as-a-Service (MaaS) platforms	2	■ Number of mobility-as-a-service platforms, i.e., integrated mobility platforms available in a particular city ■ Minimum requirements to consider a service MaaS platform: – Functionality: at least one "typical" MaaS functionality (routing, booking, payment) is available. Public transport line maps alone or departure times on stations alone without multimodal routing are not sufficient – Multimodality: at least two transport modes available on a platform required (e.g., bus and metro or suburban train and bike sharing) ■ In each city two types of MaaS platforms considered: – Multicity platforms – provide MaaS services for multiple cities. Examples: Citymapper, Moovit, Moovel, Qixxit, Ally, Trafi, City Rail Map, TripGo, Google Maps, Here WeGo – City-specific platforms – provide MaaS services for one city only. Examples: Wojhati Dubai, WienMobil Vienna, Hannovermobil, SL Stockholm, VVS Stuttgart, ZVV Zurich

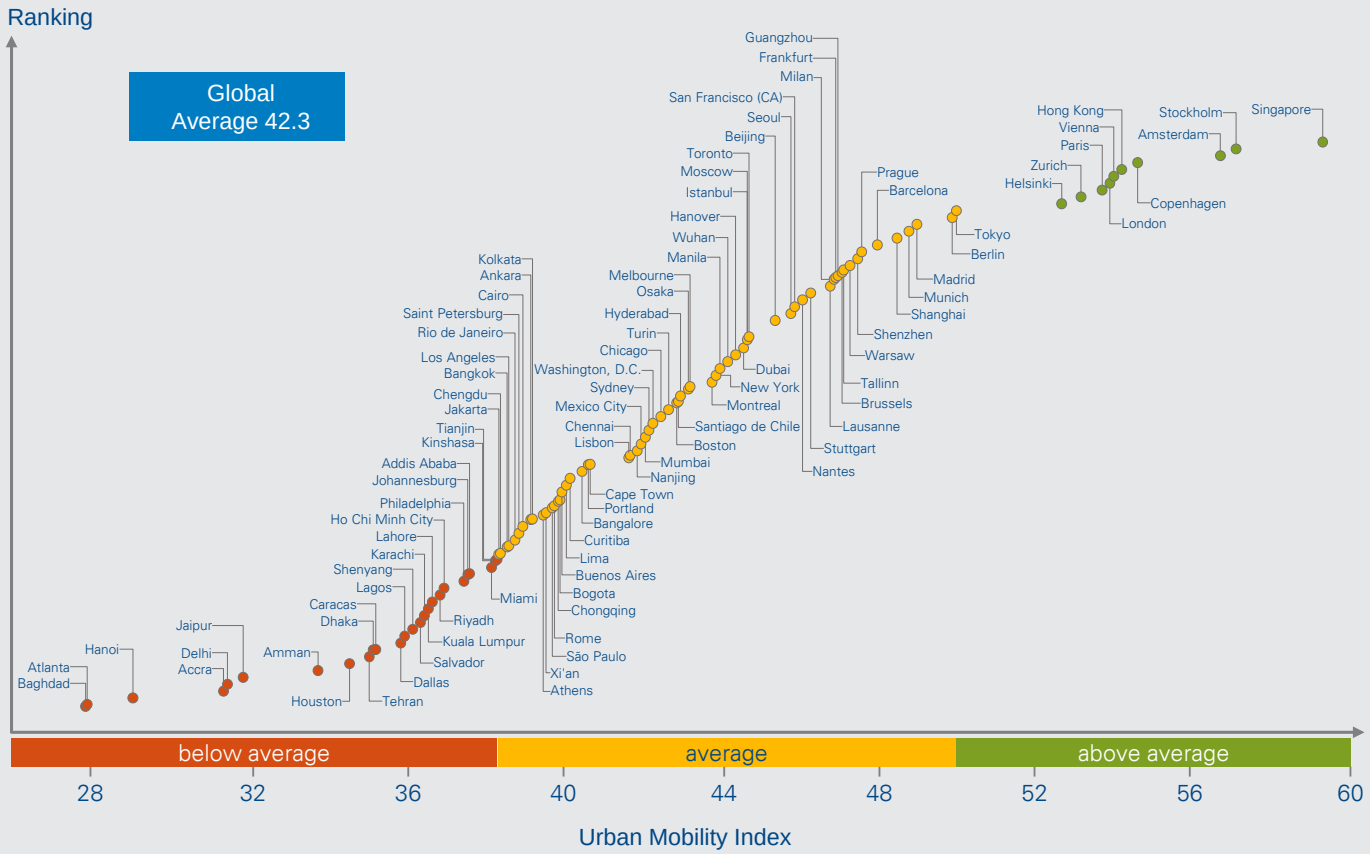
12	Bike-sharing performance	4	■ Ratio between the total number of bikes in bike-sharing systems in an urban agglomeration area and the population of this area ■ Only bikes in business-to-consumer (B2C) and administration-to-citizen (A2C) schemes are considered. Peer-to-peer (P2P) sharing is excluded
13	Car-sharing performance	4	■ Ratio between the total number of cars in car-sharing systems in an urban agglomeration area and the population of this area ■ Only cars in business-to-consumer (B2C) and administration-to-citizen (A2C) schemes are considered. Peer-to-peer (P2P) sharing is excluded ■ Both free-floating and station-based models are considered
14	Availability of peer-2-peer car-sharing services	2	■ Number of web or mobile services that enable peer-2-peer car sharing in a particular city, i.e., car owners making their vehicles available for others to rent for short periods of time ■ Examples: Getaround, Drivy, Tamyca, OuiCar, Turo, PPzuche, Baojia, Sharoo, Deways
15	Availability of e-hail services and taxi platforms	2	■ Number of e-hail services or taxi platforms available in a city ■ Examples of e-hail services: Uber, Lyft, Didi Chuxing, Ola, Careem, Gett, LeCab, Taxify, Cabify ■ Examples of taxi platforms (working only with officially registered taxi drives): mytaxi, Easy Taxi, Le Taxi, Arro, it Taxi, Taxiapp
16	Availability of ride-sharing services	2	■ Number of platforms that enable several travelers to make a journey in a single vehicle and to share its cost. This prevents the need for other travelers to drive to a location themselves (also called carpooling). ■ Examples of ride-sharing platforms: RYDE, Toogethr, Karzoo, CarpoolWorld, Flinc, Zimride
17	Availability of initiatives related to autonomous vehicles	2	■ Number of publicly announced initiatives related to piloting of self-driving vehicles such as shuttles, buses, boats, robotaxis, trains, and commercial and utility vehicles according to press clippings as per moment the index data was gathered
18	Availability of other smart mobility related initiatives	2	■ Number of smart mobility use cases as parts of respective smart city initiatives, except use cases related to self-driving vehicles, mobility platforms and other digital services considered in previous criteria ■ Examples of smart mobility initiatives: smart traffic management, smart parking, smart waste collection, smart ticketing, big data analytics for urban mobility, smart urban logistics

Performance (max. 40 points)

Criteria		Weight	Definition
19	Transport-related CO_2 emissions	4	■ Ratio between the total amount of carbon dioxide emitted by the agglomeration area p.a. as a consequence of its transport activities and its population ■ The data considers carbon dioxide emissions from the burning of fossil fuels in transportation only (sectorial approach)
20	NO_2 concentration	4	■ Annual arithmetic average of the daily concentrations of NO2 recorded at all monitoring stations within the agglomeration area
21	PM_{10} concentration	4	■ Annual mean concentration of particulate matter of less than 10 microns of diameter (PM10) [ug/m3] in a city/ agglomeration area ■ For most of cities data from the WHO Global Urban Ambient Air Pollution Database was used (update 2016). Other sources if the city was not available in the WHO Database
22	$PM_{2.5}$ concentration	4	■ Annual mean concentration of particulate matter of less than 2.5 microns of diameter (PM2.5) [ug/m3] in a city/ agglomeration area ■ For most cities data from the WHO Global Urban Ambient Air Pollution Database was used (update 2016). Other sources if the city was not available in the WHO Database
23	Traffic-related fatalities	4	■ Number of deaths related to transport, i.e., annual number of people killed as a result of transport accidents that occurred in an urban agglomeration area p.a. ■ Fatality is counted if it occurs during a period of 30 days after the accident
24	Increase of share of public transport in modal split	6	■ Increase of the percentage of the total people trips which are made daily by public transport in the last available measurement compared to its share in the second-to-last measurement ■ Only formal public transport is considered. Informal public transport (paratransit) is considered part of motorized individual transport
25	Increase of share of zero-emission in modal split	6	■ Increase of the percentage of the total people trips which are made daily by bicycle and walking in the last available measurement compared to its share in the second-to-last measurement
26	Mean travel time to work	4	■ Total number of minutes that it usually takes the person to get from home to work each day during the reference week ■ The elapsed time includes time spent waiting for public transport, picking up passengers in carpools, and in other activities related to getting to work
27	Density of vehicles registered	4	■ The ratio between the total number of passenger motorized vehicles (incl. cars, motorcycles, taxis) within the urban agglomeration and its population ■ Non-active vehicles ("scrap") excluded from the calculation

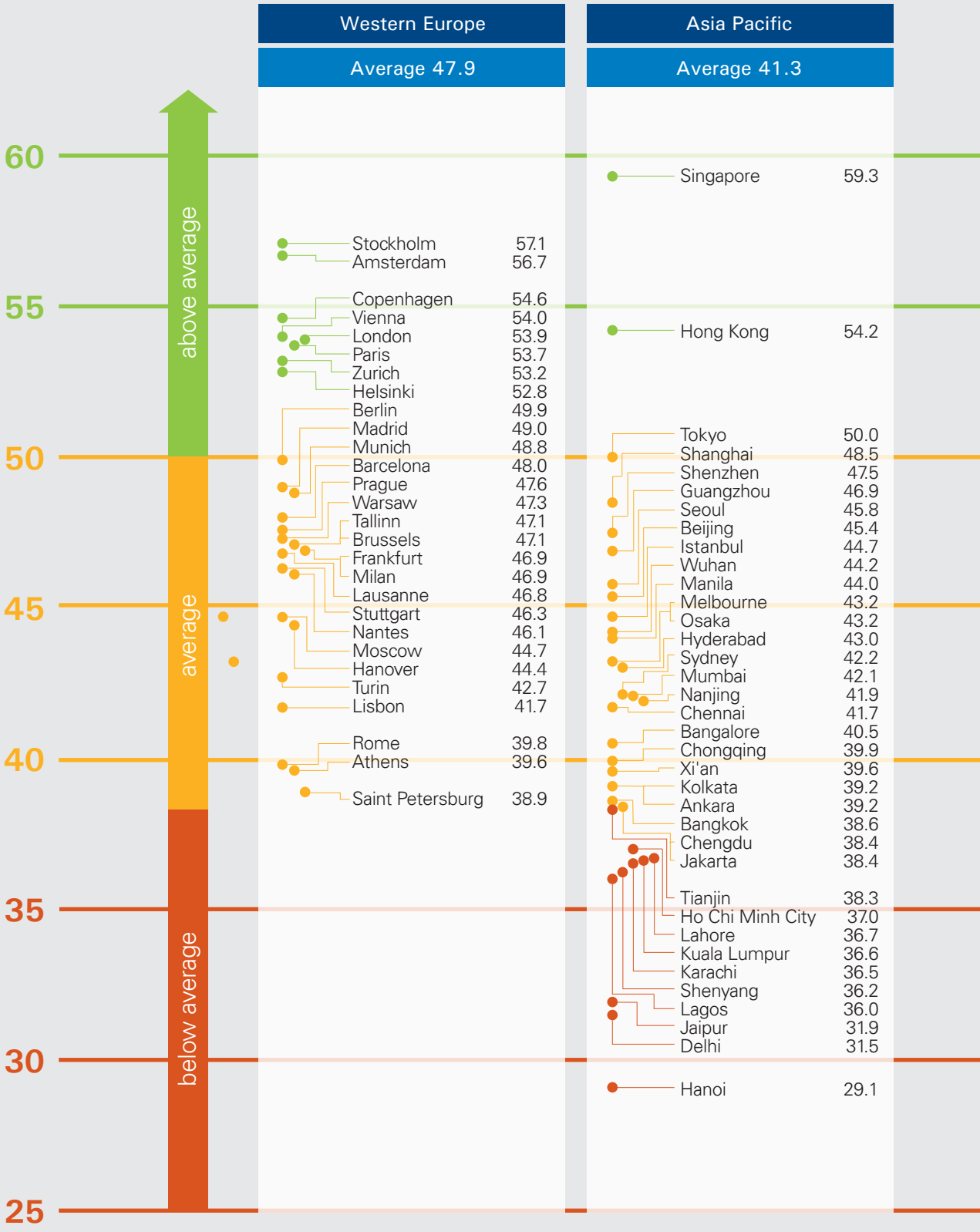
City ranking of urban mobility systems

Figure 50: Arthur D. Little Urban Mobility Index 3.0 – City ranking



The results of the Urban Mobility Index 3.0 show that the average score of the 100 cities surveyed was 42.3 out of a possible 100 points. This means that, worldwide, the average city has unleashed less than half of the potential of its urban mobility system, a state of affairs that could be remedied by applying best practices across all its operations. Cities need to work intensively on improvements to their mobility systems if they are to cope with the challenges ahead.

Figure 51: Urban Mobility Index by regions and cities




USA/Canada
Average 40.0
San Francisco (CA) 45.9
Toronto 44.7
New York 43.9
Montreal 43.8
Boston 42.9
Chicago 42.5
Washington, D.C. 42.3
Portland 40.7
Los Angeles 38.6
Miami 38.2
Philadelphia 37.5
Dallas 35.9
Houston 34.6
Atlanta 27.9
Latin America
Average 39.5
Santiago de Chile 42.9
Mexico City 42.0
Curitiba 40.2
Lima 40.1
Buenos Aires 40.0
Bogota 39.9
São Paulo 39.8
Rio de Janeiro 38.8
Salvador 36.4
Caracas 35.2
Middle East/Africa
Average 35.7/37.2
Dubai 44.6
Cape Town 40.7
Cairo 39.0
Kinshasa 38.3
Addis Ababa 37.6
Johannesburg 37.6
Riyadh 36.9
Lagos 36.0
Dhaka 35.2
Tehran 35.1
Amman 33.8
Accra 31.4
Baghdad 27.9

The highest score was achieved by the city-state of Singapore with 59.3 points, followed by Stockholm (57.1 points), Amsterdam (56.7 points), Copenhagen (54.6 points) and Hong Kong (54.2 points). This indicates that even the highest-ranking cities have considerable potential for improvement. Only 10 cities scored more than 50 points, out of which eight are European cities and two Asian.

Twenty-six cities ranked below average, and these represent the lowest tertile of the final score data set. The vast majority of the cities with mobility systems that scored below average belong to developing countries in Africa and Asia. However, several US cities can also be found in this group, invariably because the private car makes up an unhealthy proportion of their modal split. These cities need to implement sustainable mobility models and decrease their dependence on cars.

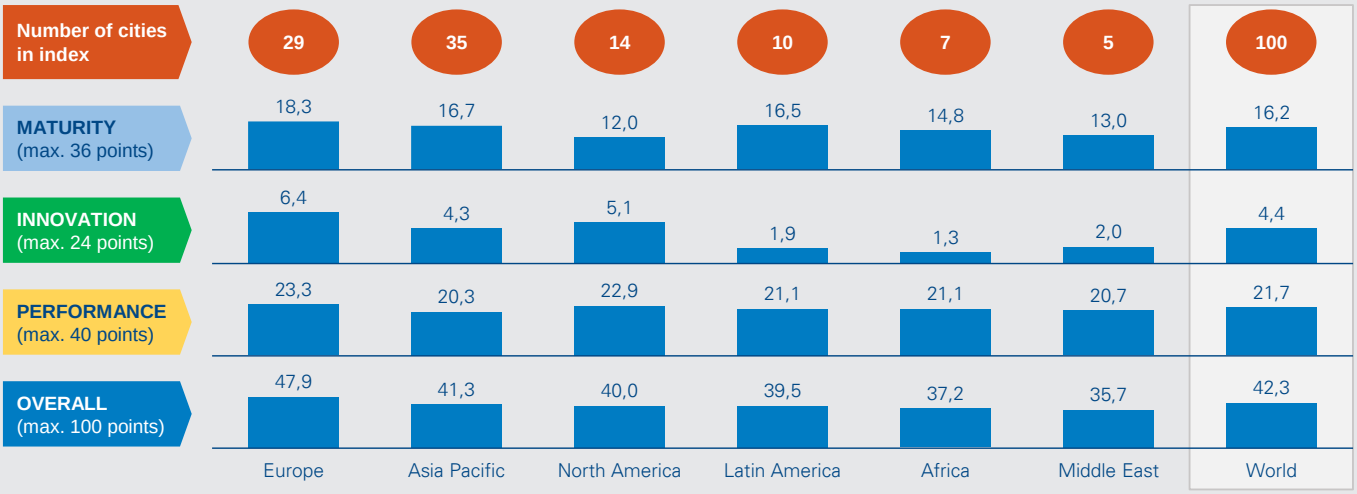
Propping up the bottom of the index with a score of 27.9 points out of a possible 100 for its mobility system was the Iraqi capital, Baghdad.

There are big differences between the top- and low-end performers in various regions:

- **Europe** achieved the highest score of all the regions. Its 29 cities scored 47.9 points on average, and eight of them made the top 10 cities worldwide. European mobility systems lead the way in maturity, innovation and performance criteria. Smaller European innovator cities that were added to the index can serve as benchmarks for most of cities worldwide. Stockholm (57.1 points), Amsterdam (56.7) and Copenhagen (54.6) head the table – while St. Petersburg (38.9 points), Athens (39.6) and Rome (39.8) are the lowest scoring European cities in the sample. Europe ranks quite highly for transport safety, with 24.0 transport-related fatalities per 1 million citizens versus a global average of 61.4. It also does well when it comes to converting its citizens from four wheels to two. The European average for cycling-network density amounts to 1.893 km per 1,000 km^2, a ratio that is twice as high as the global average of 945 km per 1,000 km^2. European cities typically have 450 shared cars – i.e., cars in car sharing systems – per million citizens, while the global average is only 177 cars. Moreover, while an average city worldwide has 4.6 mobility platforms, in Europe about 6.8 mobility platforms per city are available.
- **Asia-Pacific** is the second-best region in the world after Europe. It shows slightly below-average scores in the Innovation and Performance rankings, while scoring above average in maturity criteria. Asia-Pacific cities exhibit the broadest range in scores: from Singapore (59.3), Hong Kong (54.2) and Tokyo (50.0) at the top of the table, down to Hanoi (29.1), Delhi (31.5) and Jaipur (31.9) at the bottom. Public transport in the Asia-Pacific region is almost three times more affordable than the global average if calculated as a ratio of the cost of public transport versus the cost of private transport. The bike-sharing penetration level in Asia-Pacific is also promising: three times higher than worldwide. And while global public transport CO_2 emissions amount to 1.4 tons per capita, the Asia-Pacific value is much lower, averaging 1.0 tons per capita. Finally, Asia-Pacific cities lead the way in the penetration of smart cards per capita, with 804 cards per 1,000 citizens versus a global average of 553.
- **North American** mobility systems rank third after Europe and Asia-Pacific. Given their orientation towards cars, North American cities rank bottom worldwide in terms of maturity. With regard to innovation and performance criteria, North American cities are second best worldwide after Europe. San Francisco leads the way with 45.9 points (largely due to a high score when it comes to Innovation criteria), followed by Toronto (44.7) and New York (43.9). Transport-related CO_2 emissions in North America amount to 3,140 tons per capita, and are more than twice as high as the global average. Meanwhile, its motorization level is one of the highest in the world, with 505 cars per 1,000 citizens. However, when it comes to digital mobility services such as mobility platforms, peer-to-peer car sharing, ride sharing, e-hail and taxi services, North American cities outperform the global average.
- **Latin America** scored second after Europe in our last ranking, but has fallen behind Asia-Pacific and North America in the Urban Mobility Index 3.0. Latin American cities do not show such a broad range in scoring as, for example, Asian cities do. The best Latin American mobility system, Santiago de Chile, scores 42.9 points, followed by Mexico City (42.0) and Curitiba (40.2). Caracas ranked last within the region, with 35.2 points. Latin American cities are traditionally strong in criteria relating to public transport. For example, public transport accounts for 45 percent of the modal split on average in Latin America, while worldwide the equivalent figure is only 31 percent (an average of one hundred cities in the index). The financial attractiveness and frequency of public transport in Latin America are also well above the global average. However, it is worth pointing out that car-sharing services are almost non-existent in Latin America, with only very small fleets in Mexico City, Sao Paolo and Santiago de Chile. The same can be said of self-driving car initiatives. And the average bike-sharing penetration level is no fewer than 24 times lower than global average.
- **Africa and the Middle East** are the lowest-performing regions, with respective average point totals of 37.2 and 35.7. The best-performing mobility system in Africa can be found in Cape Town (40.7 points), while Ghana's capital,

Accra (31.4), is the last-ranked African city. Typical features of African cities include low transport safety, long travel times to work, a high share of walking in the modal split, and air quality that is below the global average. With regard to the Middle East, Dubai, with 44.6, has the best mobility system in the region and is the only city that does not belong to the below-average group. It is also worth mentioning that Dubai has notably improved its position since we published our last index, moving from rank number 56 to 34 in the current study. This significant progress is mainly due to an ambitious smart city initiative, with numerous smart-mobility innovations, the promotion of digital mobility services with an integrated mobility platform at their core, and an extensive program aimed at rolling out self-driving mobility. Currently there are 14 initiatives related to self-driving vehicles in Dubai – the highest number in the world. War-torn Baghdad came bottom of the class overall, perhaps for obvious reasons. Because many rich Middle East cities chose a "North-American path" for the development of their mobility systems and established a strong car-oriented culture, they are now starting to face considerable problems with congestion. This has triggered a rethinking of mobility-planning approaches in the Middle East and prompted the implementation of large-scale public transport and new mobility projects. But overall, Middle Eastern mobility systems are characterized by lack of cycling infrastructure (cycling-network density is eight times lower than the global average), absence of car-sharing services (though a few initiatives have been started recently), and complete absence or very low density of bike-sharing services.

Figure 52: Ranking by regions [average points overall and per dimension]



Source: Arthur D. Little Urban Mobility Index 3.0

None of the regions, except Europe, reaches 50 percent of potential maturity, which shows that all the world's cities have a long way to go in the development of their mobility systems. Europe is also at the forefront when it comes to unleashing innovation potential but, with a figure of 26 percent, even it has a long way to go. Africa, meanwhile, uses innovation levers less than any other region (only 5 percent of its innovation potential is unleashed). It is a slightly more encouraging story when it comes to performance, with Europe leading the way with a score of 23.3 out of 40 (58 percent).

Ten cities belong to the above-average group worldwide.

Arthur D Little

Figure 53: Top 10 cities with above average mobility score

		1 Singapore	2 Stockholm	3 Amsterdam	4 Copenhagen	5 Hong Kong	6 Vienna	7 London	8 Paris	9 Zurich	10 Helsinki
Maturity indicators	Fin. attract. of PT (cost of 5 km PT/ cost of 5 km car)	2.3	6.7	6.2	6.7	1.2	6.0	6.2	4.4	8.4	5.7
	Share of public transport in modal split [%]	53%	33%	18%	28%	52%	39%	37%	21%	41%	34%
	Share of zero-emission modes in modal split [%]	19%	34%	59%	43%	36%	34%	26%	40%	34%	43%
	Roads density (deviation from optimum) [km/km^2]	2.6	0.5	1.7	2.7	5.5	0.6	1.4	3.1	0.7	2.1
	Cycle path network density [km/ths km^2]	579	4,041	3,502	5,267	198	3,324	596	3,520	5,985	5,614
	Urban agglomeration density [citizens/km^2]	7.8	3.9	3.2	2.1	6.6	3.9	2.9	3.8	1.1	1.8
	Frequency of the busiest public transport line [times/ day]	237	212	155	238	349	294	468	267	145	168
	Urban mobility initiatives of public sector (0 to 10 scale)	10	10	10	10	10	10	10	10	10	10
	Urban logistics initiatives of public sector (0 to 4 scale)	4	4	4	4	4	4	4	4	4	4
Innovativeness indicators	Smart card penetration [cards/capita]	3.3	0.6	0.7	0.8	4.4	0.1	2.9	0.6	0.4	0.8
	Number of mobility platforms available	10	8	10	5	6	9	9	11	9	8
	Bike sharing performance [shared bikes/ million citizens]	5,161	2,243	1.559	1,803	273	856	1,111	2,204	401	1,271
	Car sharing performance [shared cars/million citizens]	85	458	1,250	556	0	619	271	218	954	85
	Number of peer-2-peer car sharing services available	1	3	3	2	2	2	8	11	3	2
	Number of e-hail services and taxi platforms available	7	7	2	3	4	4	8	5	5	3
	Number of ride sharing services available	6	4	2	2	3	1	5	7	3	1
	Number of initiatives related to autonomous vehicles	8	4	3	3	1	1	10	4	1	1
	Number of other smart mobility related initiatives	10	7	10	8	6	10	7	6	8	9
Performance indicators	Transport related CO_2 emissions [kg/capita]	1,278	1,116	1,097	769	1,026	1,149	935	1,354	894	1,120
	Annual average NO_2 concentration [mcg/m3]	20.7	33.3	32.5	36.5	47.0	30.8	56.1	37.0	39.5	19.2
	Annual average PM_{10} concentration [mcg/m3]	30.0	26.0	23.0	27.0	30.5	24.0	21.0	24.0	14.0	19.0
	Annual average $PM_{2.5}$ concentration [mcg/m3]	18.0	6.0	16.0	11.0	25.0	14.0	15.0	16.0	14.0	9.0
	Traffic related fatalities per 1 million citizens	27.1	4.7	11.0	7.1	16.7	6.6	17.7	17.3	14.4	10.2
	Dynamics of share public transport in modal split [%]	+22%	-7%	-10%	+27%	+14%	+12%	0%	+3%	+5%	+6%
	Dynamics zero-emission modes in modal split [%]	-19%	+89%	+40%	+13%	-4%	+2%	+13%	+15%	+10%	+10%
	Mean travel time to work [minutes]	44.6	39.9	28.2	30.5	44.0	26.2	48.0	41.3	32.2	35.0
	Density of vehicles registered [vehicles/capita]	0.17	0.41	0.32	0.27	0.11	0.37	0.40	0.45	0.43	0.45
	Overall score	59.3	57.1	56.7	54.6	54.2	54.0	53.9	53.7	53.2	52.8

Singapore – study winner: 59.3 points; 1 out of 100 worldwide, 1 out of 35 in Asia-Pacific.

The Lion City has made considerable progress since our Urban Mobility Index 2.0 study and can be seen as the showcase for the future of urban mobility. While the city had about 100 shared bikes in 2013, that fleet has now grown to some 29,000. The main reason for this is, of course, a global bike-sharing boom and the enormous growth of companies such as Mobike, Ofo and oBike.

But the move that has made Singapore a media darling in the world of mobility is its pioneering approach to autonomous driving. It has launched a wide range of self-driving vehicle initiatives ranging from pilot schemes of autonomous shuttles, buses and robotaxis to commercial and utility vehicles. To implement these initiatives the public and private sectors have come together to create a broad partner ecosystem. The pilots are supported by the Government of Singapore, which has a clear strategy for the proliferation of self-driving vehicles and has gone much further than other countries in reducing the levels of red tape that constrain their development. As is well known, this comparatively tiny city-state suffers from a shortage of land and cannot afford to build lots of new road infrastructure while its population is constantly growing. Self-driving vehicles are expected to improve urban mobility efficiency and thus reduce the demand for road and parking spaces while increasing quality of life. Self-driving mobility can also solve another of Singapore's problems – a chronic lack of labor to operate public-transport and logistics services.

Other smart-mobility initiatives Singapore has leveraged to implement its vision of a "car-lite society" include mobility big-data analytics, integrated transport management systems, pedestrian detection systems, V2X communication, predictive transport and others.

What's more, Singapore has one of the largest penetration levels of multimodal transport smart cards in the world. There are more than 17 million CEPAS cards in circulation among a population of 5.6 million people – a total that amounts to an average of more than three per person. Mobility platforms available in the city include Citymapper, Moovit, City Rail Map, NextRide, LTA MyTransport, and How2Go. Among the ride-sharing platforms operating in Singapore, the most popular are RYDE, CarpoolKing, CarpoolSG, CarpoolWorld and Locanto.

These factors, together with traditionally high car taxes and road pricing, which act as a deterrent to private car users, helped Singapore move from sixth place in the 2.0 index to first place in the 3.0 version.

However, while the city won the "Innovativeness group", it ranks sixth in the "Maturity group" and tenth in the "Performance group". So where is the room for improvement in Singapore's mobility system? Cycling could be encouraged, for a start. While the global average for cycling-network density is slightly over 1 km/km^2, Singapore's network amounts to half that ratio. Car-sharing is also under-developed. Among the 100 cities surveyed, the average number of shared cars per million citizens in the Urban Mobility Index is 177, while in Singapore the figure is 85. Last but not least, mean travel time to work in Singapore is the second lowest after London within the top 10 cities.

Stockholm – 57.1 points; 2 out of 100 worldwide, 1 out of 29 in Europe.

The Swedish capital kept the second place it achieved in the previous mobility systems ranking and distinguished itself by coming top in the Performance ranking, second in the Maturity ranking and sixth in the Innovativeness ranking.

Out of all 100 cities surveyed, Stockholm has the safest mobility system – i.e., the lowest share of transport-related fatalities per million citizens, with a total of 4.7 compared to the European average of 24.0 and the global average of 61.4. It also has a well-balanced modal split, with 34 percent of trips attributed to motorized individual transport, 33 percent to public transport and the remaining 34 percent to walking and cycling. The air quality in Stockholm is good too, with regard to NO_2, PM10 and $PM_{2.5}$ levels. And the concentration of fine particles with diameters of 2.5 µm or less ($PM_{2.5}$), a highly dangerous pollutant, is the lowest among all 100 cities surveyed – 6 mcg/m^3 versus a global average of 35 mcg/m^3.

Stockholm's strategy is to be considered good practice in urban mobility and urban freight, setting ambitious goals relating to capacity, accessibility, attractiveness and sustainability. As a part of its smart and connected city plan, Stockholm is also implementing a broad range of smart mobility initiatives, from smart traffic management and traffic-light priority for buses to a congestion-pricing system and smart lighting for bicycle paths. Mobility platforms used by locals and visitors alike include global platforms such as Citymapper, Moovit and TripGo, plus successful local services such as SL Journey planner, TravelSmart and SLife. Well-known start-ups such as UbiGo have also chosen Stockholm to be their pilot cities.

It is also worth mentioning a self-driving shuttle that began test runs under real-world conditions in mixed traffic early in 2018.

In order to win the next global urban mobility ranking, Stockholm will need to further improve its innovativeness level. Car-sharing services require more promotion, as do digital mobility services, such as MaaS platforms and peer-to-peer and ride-sharing platforms. It should also work on its smart mobility initiatives, including autonomous driving. This will allow Stockholm to unleash the potential hidden in its transport infrastructure capacities, as well as reduce investments in new road and rail lines.

Amsterdam – 56.7 points; 3 out of 100 worldwide, 2 out of 29 in Europe.

The capital of the Netherlands, well known worldwide for its cycling-oriented mobility system, has again ranked third in the urban mobility index.

The proportion of non-motorized transport (NMT) in Amsterdam's modal split reached almost 60 percent, with cycling accounting for more than half of this figure. This is the highest level achieved by any of the developed cities, i.e., cities with GDPs per capita of more than US$25,000, where NMT on average amounts to 24 percent of the modal split. At the same time, Amsterdam has the lowest share of public transport in the modal split of all the top 10 cities – only 18 percent, and that number is declining. Also worth mentioning are the good safety record of Amsterdam's mobility system and its highly dense cycle-path network – which totals 767 km – on which Amsterdammers cycle 2 million kilometers every day.

The city also has the second-highest penetration of shared cars in the world after Stuttgart: 1,250 shared cars per million citizens in Amsterdam versus European and global averages of 450 and 177, respectively. Another highlight of Amsterdam's mobility system is an extremely low level of car ownership: only one in four of its citizens, owns a car compared to a rate of one in two urban citizens in Europe as a whole.

Among the city's mobility platforms, local services include GVB and Amsterdam Transit, and global platforms such as Moovit, Moovel and Citymapper are also available. A well-known start-up called MaaS Global has recently launched a pilot of its Whim platform in Amsterdam. When it comes to peer-to-peer car sharing, citizens use platforms such as SnappCar and Wego, and for ride-sharing, Toogethr and Karzoo.

Other smart mobility elements of Amsterdam's comprehensive smart city initiative include smart waste collection, smart parking, smart crowd management, and smart city logistics. With regard to self-driving vehicles, the city is not only piloting autonomous buses and shuttles, but also autonomous boats.

Copenhagen – 54.6 points; 4 out of 100 worldwide, 3 out of 29 in Europe.

The Danish capital's position in the ranking remains unchanged at fourth in the world. In the maturity ranking Copenhagen's mobility system ranks eighth, in the performance ranking third, and in the innovativeness ranking 15th worldwide.

Like Amsterdam, Copenhagen has a claim to the title "bicycle capital of the world", with cycling firmly implanted in its citizens' DNA. Our last measurement showed that cycling accounted for an unprecedented 36 percent of the modal split in Copenhagen. Needless to say, the city has one of the densest cycle-path networks worldwide. Public transport plays a significant role in its mobility system too, with a 28 percent share of the modal split.

Copenhagen also scores well in terms of environmental performance, and it has ambitious plans to become carbon-neutral by 2025. Good progress has already been made towards this goal. The level of carbon emissions recorded in 1990 has been reduced by over 40 percent, but there is still some way to go if the city is to become world's first CO_2-free capital. The transport sector has an important contribution to make in pursuit of this aim. In the coming years substantial investments are planned for both public transport and the cycling infrastructure, and environmental regulation will get even more strict. An expansion of the shared economy, smart parking, alternative energies and other initiatives will all help Copenhagen in its bid to reach its highly ambitious goal.

The Danish capital's smart city initiative also involves rolling out intelligent transportation systems for bicycles, smart lighting for cycling paths, traffic optimization based on big-data analytics, and smart asset tracking. The city is also known for pilot schemes of self-driving vehicles, be it a 3D-printed shuttle Olli or a BMW i3, as a part of the DriveNow car-sharing service, and it even has plans to develop autonomous ships.

However, the level of car-sharing penetration in Copenhagen still lags behind European good-practice cities. And the number of ride sharing, peer-to-peer car sharing, and e-hailing services is also low compared to other European cities.

Hong Kong – 54.2 points; 5 out of 100 worldwide, 2 out of 35 in Asia-Pacific.

Hong Kong, which came top in two previous editions of the Urban Mobility Index, has lost its number-one spot and dropped to rank 5. That said, most of Hong Kong's key indicators remained stable. The city still has one of the most iconic modal splits in the world and a motorization level that is the envy of many other cities. In addition, the penetration level of the Octopus multimodal mobility card continues to grow.

But, while cycling is a popular activity in Hong Kong, the city's cycle-path network has one of the lowest densities in the world – 198 km per thousand km^2 compared to a global average of 943. There is also room for improvement when it comes to bike-sharing. While the global bike-sharing penetration rate has grown tenfold since the last urban mobility ranking – from 385 bikes per million citizens in 2013 to 3,988 in 2017 – in Hong Kong there are currently about 273 shared bikes per million people. However, this does represent considerable progress, as in 2013 the city did not have any bike-sharing service at all.

Car-sharing is another issue. At the time the index data was gathered, Hong Kong was one of the few developed cities in the world that still did not have any business-to-consumer car-sharing services. However, the city does have two peer-2-peer car sharing platforms: Carshare.hk and ECrent.

With regard to smart mobility initiatives, Hong Kong is actively working on real-time data collection with intelligent transport systems, the integration of sensors and provisioning of new services on public transport interchanges, the development of an integrated mobility platform, smart parking, a smart traffic signal system, smart traffic enforcement, tests of connected vehicles including smart buses, and a feasibility study of an electronic road-pricing system.

Although Hong Kong has been a test bed for pilot schemes of self-driving vehicles for several automotive OEMs, the city is so far not putting an emphasis on innovations related to self-driving public transport and robotaxis.

Vienna – 54.0 points; 6 out of 100 worldwide, 4 out of 29 in Europe.

With public transport accounting for a 39 percent share of the modal split and non-motorized transport – of which 7 percent is cycling – contributing another 34 percent, Vienna's modal split is a benchmark for many cities worldwide. High safety of traffic, combined with a comparatively low mean travel time to work, ensures a high quality of life in the Austrian capital. What's more, the density of the city's cycling network is one of highest in the world – three times higher than the global average, and twice as high as the European average.

In 2015 the city introduced a multimodal mobility platform called WienMobil that was branded SMILE in the piloting phase. WienMobil can be used to access not only public-transport services, but also parking, charging stations for electric vehicles, taxis, car-sharing, car-rental and bike-sharing. The platform back-end system, Upstream, has also been deployed in Graz and is expected to be deployed across all major Austrian cities by 2020.

Multiple car-sharing providers operate in the city, including car2go, DriveNow, Zipcar and Stadtauto. Ofo and Obike have recently launched their bike-sharing offerings in competition with Citybike, which has been operating in the city for 15 years. Peer-2-peer sharing services are offered by Drivy and carsharing24/7.

Vienna's urban mobility strategy is quite ambitious. In the run-up to 2025, the city is striving to achieve "Vision Zero" with regard to transport safety, i.e., no more traffic-related fatalities. Another goal is a fair reallocation of street space, of which 65 percent is currently used by motorized individual transport and for parking purposes, in favor of environmental modes of transport. The city is also aiming to increase considerably the density of shared cars and bikes, develop new cycling routes for long-distance mobility and implement cargo-bike concepts.

London – 53.9 points; 7 out of 100 worldwide, 5 out of 29 in Europe.

The share of public transport in London's modal split has grown since the last ranking to reach 37 percent. The city's goal is to increase this figure to 40 percent and to triple the share of bike journeys in the modal split, from 2 percent to 6 percent.

London ranks second in the innovativeness ranking thanks to the fact that it has one of the largest numbers of peer-2-peer car sharing platforms, ride-sharing platforms, e-hail and taxi platforms, and multimodal mobility platforms worldwide.

The city also boasts a diverse range of autonomous vehicle services and pilot schemes. In 2011, London was one of first cities to introduce a personal rapid transit (PRT) system with self-driving carpods at Heathrow Airport's Terminal 5. A test of another driverless shuttle was carried out in April 2017 in Greenwich as a part of the GATEway initiative and, in

September of the same year, Navya's ARMA shuttles were piloted in London's Olympic Park. Another promising project is StreetWise, a robotaxi service being developed by Transport for London in partnership with multiple research institutions, which is due to be piloted at the end of 2019. This initiative is expected to cut congestion and free up parking spaces in London. Multiple automotive OEMs, such as Volvo and Nissan, are also testing self-driving features of their vehicles on the city's streets.

Other pilots related to autonomous driving technology include self-driving vans, or so-called cargo pods, that deliver groceries to online shoppers; tests of self-driving trains on London's rail network; and autonomous robots from Starship and Hermes that deliver parcels or make other local deliveries door-to-door.

In cooperation with a broad range of research institutions, London's authorities are working on big-data analytics using customer and smart-card data, in a bid to optimize their mobility offerings, increase customer satisfaction, and improve disruption and operations management, as well as the strategic planning of London's mobility systems.

Paris – 53.7 points; 8 out of 100 worldwide, 6 out of 29 in Europe.

The French capital ranks 8 in the current study, and in the innovativeness ranking it comes fourth worldwide. Compared to the last ranking, the safety level of Paris's mobility system has also improved: 17.3 transport-related fatalities per million citizens now versus 23.9 last time. The city is also investing intensively in the expansion of its public-transport infrastructure. A well-known initiative is the Grand Paris Express – currently the largest urban transport project in Europe – which is aimed at constructing six new metro lines for autonomous trains at a cost of about 35 billion Euros. The plan is for this new super metro system to go live in 2024, when Paris will be hosting the summer Olympic Games. It is estimated that about 150,000 cars will be removed from the city's roads after the new metro system goes operational.

Air pollution has long been a big problem for Paris. In December 2016, in order to ease PM_{10} concentrations, the city decided to ban cars with either odd or even number-plates for several days, and has made all public transport completely free. To improve its sustainability level and reduce greenhouse gases, the city administration has also decided to banish all diesel and petrol vehicles from its streets by 2030. Thus, the most visited city in the world will allow only electrically driven vehicles just 12 years from now.

Paris has third-highest penetration of shared bikes in Europe after Brussels and Stockholm: 2,204 shared bikes per million citizens in Paris versus the European average of 1,011. Citizens and visitors use numerous multimodal mobility platforms and applications such as Citymapper, City Rail Map, TripGo, Moovit, Here WeGo, Transit, RATP and Next Stop. Alongside the all-powerful Uber, e-hail services are being provided by leCab, Drive and SnapCar. In a bid to break Uber's stranglehold on this sector, the French government has launched a popular taxi platform called "Le Taxi".

Private-car sharing is well developed in the capital of France. Owners can share their car with others using 11 peer-2-peer platforms – the largest number observed worldwide. Examples of such platforms include OuiCar, Drivy, koolicar, Deways and carsonar.

Paris is also well known for innovative transportation solutions such as the first self-driving bus line, electric taxi boats and various sustainable urban logistics concepts.

Zurich – 53.2 points; 9 out of 100 worldwide, 7 out of 29 in Europe.

Compared to the last ranking, the largest city in Switzerland could further reduce the share of motorized individual transport in the modal split from 30 percent to 25 percent, and aims to cut that figure to 20 percent by 2025. Meanwhile, the share of cycling in the modal split has doubled since 2010, from 4 to 8 percent. To achieve its ambitious targets relating to a "greening" of the modal split, the city is conducting a strict mobility demand management policy with a view to decreasing the number of on-street parking places available. In one city referendum, citizens voted to limit parking-space provisioning to one place for each 1,200 m^2. Another important goal of Zurich's mobility systems is to promote walking by increasing accessibility in the city, investing in footpath infrastructure and implementing pedestrian-centric designs for public spaces.

Zurich's environmental performance has been impressive too, due to the city's public-transport systems, which are recognized to be among the best in the world. Less than one ton of CO_2 per capita are being emitted currently in the city, 30 percent of which is caused by the transport sector. The plan is to cut this emissions rate to one ton of CO_2 per capita by 2050, thus ensuring a high level of sustainability and a good quality of life in Zurich. To achieve this goal, energy usage per citizen will have to be decreased to 2,000 watts – a so-called "2,000 watt-society" – transportation will need to be

low-carbon, and motorized individual transport will have to be reduced to minimum.

Finally, Zurich is working intensively on piloting a range of innovative technologies, such as self-driving shuttles, drones for home-delivery services and robots for the last mile in postal logistics.

Helsinki – 52.8 points; 10 out of 100 worldwide, 8 out of 29 in Europe.

Finland's capital, which is also its largest city and famed for its high quality of living, ranks 10 in the current study. High traffic safety, a large share of environmentally friendly modes of transport, constantly shrinking use of motorized individual transport, and good-practice environmental performance characterize Helsinki's mobility system.

Car-sharing is still not very popular in Helsinki, but the penetration level of shared cars is rising, especially after DriveNow, a pan-European joint venture between BMW and car-hire company Sixt, began operating in the city. Helsinki's bike-sharing service was also recently extended to offer 1,500 bikes from 150 stations.

Finnish start-up MaaS Global, which aims to take mobility platforms up to the next level, is piloting its Whim app in Helsinki. "The Netflix of transportation" offers three packages – Whim to Go, Whim Urban and Whim Unlimited – each for a different monthly price and with a different number of rides by taxi, public transport, shared bikes and other services. Other apps that can be used in Helsinki include Moovel, Moovit, Transit, TripGo, Google Maps, OnTimely, Nysse and HSL. But these often offer journey-planner functionality without monthly packages, and sometimes without payment options.

The city of Helsinki is also known for its smart city initiative and a test bed in the Kalasatama district with a broad range of smart mobility options. Those include hands-free smart ticketing (be-in-be-out) for ferry passengers, dynamic parking spaces, analytics on mobile movement data, smart management of truck movement to reduce congestion, smart containers and even the RoboBusLine – a scheduled public-transit service which uses electric self-driving buses.

Overall index results are not necessarily similar to rankings for three different criteria groups: **maturity**, **innovativeness** and **performance** of urban mobility systems.

Figure 54: Ranking by dimensions

Top 10 cities by three groups of criteria

Maturity [max. 36 points]		**Innovation** [max. 24 points]		**Performance** [max. 40 points]	
1. Hong Kong	22.0	1. Singapore	13.9	1. Stockholm	26.4
2. Stockholm	21.4	2. London	11.9	2. Amsterdam	26.2
3. Vienna	21.2	3. Amsterdam	10.9	3. Copenhagen	26.2
4. Helsinki	21.2	4. Paris	10.5	4. New York	25.5
5. Warsaw	20.8	5. Shanghai	9.3	5. Vienna	25.4
6. Singapore	20.6	6. Stockholm	9.2	6. Tallinn	25.2
7. Prague	20.5	7. San Francisco	8.9	7. Helsinki	25.2
8. Copenhagen	20.4	8. Brussels	8.7	8. Osaka	25.1
9. Zurich	20.4	9. Berlin	8.5	9. Barcelona	24.9
10. Amsterdam	19.7	10. Beijing	8.3	10. Singapore	24.8

Source: Arthur D. Little Urban Mobility Index 3.0

The city of Hong Kong has the most mature mobility system, followed by Stockholm and Vienna. In the top 10 maturity ranking there are two cities that are not in the overall top 10: Warsaw and Prague. Both these cities have frequent and financially attractive public-transport services, which has led to a large share of public transport in the modal split: 55 percent in Warsaw and 42 percent in Prague.

Innovation criteria reflect emerging physical and digital mobility services. Singapore leads the innovation ranking, followed by London and Amsterdam. Six of the cities in the top 10 innovation ranking are not in the overall top 10:

- Shanghai has no fewer than 600,000 bikes in its bike sharing system. However, other Chinese cities boast similarly high numbers of bikes: about 700,000 in Beijing, 800,000 in Guangzhou, 890,000 in Shenzhen, and 700,000 in Wuhan. Shanghai also has an above-average number of e-hail services and peer-2-peer car sharing platforms, as well as 67 million multimodal mobility smart cards in circulation.
- San Francisco is strong in all emerging digital mobility services, as well as in smart mobility use cases supported by many start-ups and academic institutions in Silicon Valley.
- Brussels has more than 4,000 shared bikes per million citizens, which is the highest total in Europe. Moreover, there are about 1.6 million MOBIB mobility cards in circulation in the Brussels agglomeration area, and an extensive smart city initiative is in place.
- Berlin has numerous car-sharing services – car2go, DriveNow, Flinkster, Multicity, Stadtmobil, Citeecar, Hertz, Cambio – and a high penetration of shared bikes per million citizens. In addition, there are 10 mobility platforms at the disposal of the citizens and visitors of Berlin.
- Beijing, as we have seen, has a huge supply of shared bikes. Besides this, there are about 30 million mobility cards in circulation, and it has numerous e-hail services.
- Stuttgart, as a home city of Daimler and Mercedes-Benz, has the highest penetration rate of shared cars among all 100 cities surveyed – 1,440 cars per million citizens – as well as eight mobility platforms.

Based on its performance ranking, Stockholm has the most high performing mobility system worldwide. In the performance ranking there are four European, North American and Asian cities that are not in the overall top 10:

- New York has a relatively safe mobility system with good air quality. There are only 243 cars per 1,000 citizens in New York, which is the fifth-lowest level of all the cities in the developed economies after Hong Kong, Singapore, Stockholm and Amsterdam.
- Tallinn, the capital of Estonia, recently significantly increased public transport's share of its modal split to 40 percent by offering all journeys free of charge in what has become a globally renowned experiment. The new policy was introduced on January 1, 2013, after 76 percent of voters supported the plan in a referendum. Annual losses resulting from this measure amount to 12 million euros (about US$14.7 million), a figure that is being covered by subsidies.
- Osaka has the third-safest mobility system in Asia-Pacific after Sydney and Tokyo. Moreover, Osaka's transport-related CO_2 emissions fall below half of the global average.
- Barcelona has significantly improved its modal split in recent years: the share of public transport has risen from 20 to 24 percent, and non-motorized transport from 45 to 52 percent. Meanwhile, the city's transport-related CO_2 emissions are running at half the European average.

Conclusions from Arthur D. Little's Urban Mobility Index

Since the last index was published in 2013, some remarkable progress has been made in urban mobility. Having analyzed the data for the 84 cities that were included in both Urban Mobility Indexes 2.0 and 3.0, we can offer the following insight:

- The global share of motorized individual transport has decreased from 42 to 40 percent of the modal split, a welcome development. During the same time period, the share of public transport increased from 29 to 31 percent, while non-motorized transport remained stable at 29 percent.
- Average transport-related CO_2 emissions per capita decreased by 3 percent – from 1,506 to 1,464 tons.
- The density of cycling networks in the 84 cities increased by 26 percent – from 756 to 955 km per 1,000 km^2.
- The penetration rate of multimodal mobility cards increased by 27 percent – from 442 to 560 cards per 1,000 citizens.
- The penetration level of car sharing increased by 54 percent – from 116 to 179 shared cars per million citizens. At the same time, the penetration level of bike sharing increased by a factor of 10.7 – from 385 to 4,114 shared bikes per million citizens.
- The motorization level has increased by 5 percent, driven by dynamics in developing regions, from 380 to 398 cars per thousand citizens.

While Singapore ranked top in the study, it has unleashed only 59 percent of its existing potential and thus still has significant room for improvement. Overall, the average urban mobility system has unleashed less than half of its existing potential. European mobility systems have performed best worldwide, but Asia-Pacific and North America are catching up – in the current index they rank above Latin American mobility systems. Modal splits have become healthier, but a trend towards increasing motorization, especially in developing regions, should be curbed in the future. New digital and physical mobility services are growing considerably and expected to effect a quantum shift in mobility systems in the long term.

However, an ideal urban mobility system does not yet exist. What would a city that performed well across all criteria look like? A hypothetical best-in-class urban mobility system would:

- Be as safe as the one in Stockholm, or even achieve "Vision Zero" with regard to transport safety, i.e., no traffic-related fatalities at all.
- Have short travel times like in Nantes or Portland.
- Provide public transport services that are as financially attractive as they are in Chinese cities, or even completely free of charge, as they are in the Estonian capital of Tallinn. At the same time its public-transport service would be as frequent as those of London or Moscow, or even operate on demand along the lines of the self-driving shuttles and robotaxis that are being piloted currently.
- Have a modal split like that of Hong Kong or Tokyo, leading to low transport-related CO_2 emissions.
- Have air quality as good as that to be found in US cities.
- Have dense cycling networks like Copenhagen, Helsinki and Stockholm.
- Establish a multimodal mobility culture or "car-light society" based on high penetration levels of multimodal mobility cards and mobility platforms.
- Offer extensive car-sharing schemes, like those available in German or Dutch cities, and ubiquitous bike-sharing services similar to the ones offered in China.
- Roll out as many peer-to-peer car-sharing initiatives as can be seen in the French cities of Paris and Nantes.
- Implement numerous smart mobility use cases, following the example of Amsterdam and Singapore.
- Be as active in the piloting of new mobility forms such as self-driving vehicles, as in London or Dubai.

Arthur D Little

Arthur D. Little's Future of Mobility Lab

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

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

Arthur D. Little FUM lab activities and service offerings include:

- Act as a think tank for the development of global studies on mobility futures, including the development of the Future of Urban Mobility Indexes.
- Support transport authorities (at national, regional or city level) in designing sustainable mobility policies (visions, strategies and roadmaps).
- Support public and private actors in strategy definition and development of mobility ecosystems (i.e., integrated mobility platforms or last-mile delivery ecosystems).
- Financial business case and go-to-market strategies for innovative mobility solutions.

Figure 55: Future of Mobility Lab

Arthur D. Little Future Mobility Lab

The Future of Urban Mobility Lab is **Arthur D. Little's contribution to tackling the urban mobility challenge**. Arthur D. Little aims to use its Future Lab to support cities and nations in shaping the extended mobility ecosystems of tomorrow and as a catalyst to enable and facilitate an open dialogue between urban mobility stakeholders.

– Ignacio Garcia Alves, Arthur D. Little Global CEO

Future of Mobility Lab Offering

1. **Assessment of mobility performance (incl. Urban Mobility Index)**
2. **Definition of national/regional/city urban mobility strategies and roadmaps**
3. **Opportunity assessment and development of innovative mobility ecosystems**
4. **Definition of urban logistics strategies**
5. **Business cases for innovative business models and technologies**

Source: Arthur D. Little

Publications

Figure 56: Arthur D. Little's Future of Mobility Lab publications

Since its inception, Arthur D. Little's Future of Mobility Lab has regularly released landmark studies on mobility futures.

The first global Future of Mobility study[41], published in 2011, highlighted the mobility challenges cities faced on a worldwide basis and introduced the first Arthur D. Little Urban Mobility Index, which assessed the mobility maturity and performances of 66 cities worldwide and triggered high interest within the industry across the globe.

January 2014 saw the release of the second version of the "Future of Urban Mobility" study[42], including an updated version of the Urban Mobility Index, with a wider scope of 84 cities worldwide, as well as an extended set of criteria, which indicated that there was still significant potential for improvement. The report highlights what is holding cities back, and, together with its partner, the UITP – the International Association of Public Transport – identifies three strategic directions for cities to better shape the future of urban mobility. The study also describes 25 imperatives for public-transport authorities to consider when defining sustainable urban mobility policies. A focus report on strategic directions to address China's mobility challenges[43], as well as a contribution to Michelin Challenge Bibendum Global Summit's green book on innovative mobility[44], were also released that year.

A study focused on urban logistics was published in 2015[45], looking at how cities, transporters and retailers alike could unlock value from last-mile delivery for cities. The report highlighted the challenges and opportunities associated with last-mile delivery of goods in cities, and analyzed the availability of solutions to devise appropriate strategies for urban logistics, with a specific focus on the contributions and rewards for each player in this new ecosystem.

In March 2017, a focused study was published on the Future of Automotive Mobility[46], based on a global survey of 6,500 participants, including customers, industry players and regulators. This report examines how the megatrends of electric mobility, car sharing and autonomous driving are likely to impact the global automotive ecosystem.

This third edition of the Future of Mobility study, published in March 2018, examines societal and technology trends, as well as new mobility solutions, and reflects on their likely impact on future mobility ecosystems. It also includes a new edition of Arthur D. Little's Urban Mobility Index, this time covering 100 cities worldwide, and an extended set of criteria, now increasingly concerned with innovation in urban mobility systems. In conjunction with the UITP, it also arrived at 12 strategic imperatives for mobility solution operators to consider when defining their visions and strategies to remain competitive in the short term and relevant in the long term within extended mobility systems.

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References

Arthur D. Little, "The Future of Urban Mobility – Towards networked, multimodal cities of 2050", 2011 [1, 20, 41]

Arthur D. Little and UITP, "The Future of Urban Mobility 2.0 – Imperatives to shape extended mobility ecosystems of tomorrow", 2014 [2, 22, 23, 31, 42]

BP Energy Outlook, "Outlook to 2035", 2016 [3]

United Nations, "World population prospects, key findings & advance tables", 2017 [4]

Global Market Insights, "Car sharing market size, industry trends report 2024", 2017 [5]

World Economic Forum and Boston Consulting Group, "Self-driving vehicles in a urban context", 2015 [6]

Barclays Research Insights, "Disruptive mobility, a scenario for 2040", 2015 [7]

The Earth Institute, Columbia University, "Transforming personal mobility", 2013 [7]

UBS Research, "How disruptive will a mass adoption of robotaxis be?", 2017 [7]

Deloitte Insights, "The future of mobility, how transportation technology and social trends are creating a new business ecosystem", 2015 [7]

University of Michigan, "Transforming mobility, the signal in the noise", 2015 [7]

Business Insider, ARK Invest Research, "Estimated cost per mile of vehicle services for consumers", 2015 [7]

Rocky Mountain Institute, "Peak car ownership, the market opportunity of electric automated mobility services", 2016 [7]

Mckinsey Research Institute, "An integrated perspective on the future of mobility", 2016 [8]

UITP Policy Brief "Autonomous vehicles: a potential game changer for urban mobility", 2017 [9]

Technische Universität Darmstadt (Germany), "Demand oriented mobility solutions for rural areas using autonomous vehicles - feasibility of the implementation of SAVs as sole mobility solutions", 2017 [10]

Braunschweig University, "Verkehrliche Wirkung autonomer Fahrzeuge", 2015 [11]

California University, Impacts of cooperative adaptive cruise control on freeway traffic flow, 2012 [11]

Princeton University, FP Think working group members, "Effect of next-generation vehicles on travel demand and highway capacity, 2014 [11]

Columbia University, Department of Electrical Engineering, "Highway capacity benefits from using vehicle-to-vehicle communication and sensors for collision avoidance", 2011 [11]

OECD, International Transport Forum, "Urban mobility system upgrade, how shared self-driving cars could change city traffic", 2015 [12]

Reportlinker, "Strategic analysis of smart parking market in Europe and North America", 2015 [13]

Audi Urban Future, "Automated parking garage for self-driving cars to Boston-area", 2014 [14]

WSP | Parsons Brinckerhoff, "How the digital railway can bring a 40% increase in line capacity" [15]

Goldman Sachs Global Investment Research, "Rethinking mobility, the 'pay-as-you-go' car: ride hailing just the start", 2017 [16]

Arthur D. Little, "The future of automotive mobility - winning the power play in tomorrow's radically changed automotive ecosystem", 2017 [17, 46]

OECD, International Transport Forum, "ITF transport outlook", 2017 [18]

INRIX, "Global traffic scorecard", 2017 [19]

Google, Apple, Facebook and Amazon [21]

Arthur D. Little, "The WHY strategy: there is no strategy without meaning", viewpoint, 2017 [24]

UITP Action Point, "Brand alignment matters in public transport", 2017 [25]

UITP Commission on Marketing and Product Development, "Thematic dossier customer experience", 2017 [26]

UITP Action Point "Building a culture of service excellence to develop a public transport business", 2017 [27, 28, 29]

Arthur D. Little, "Efficiency and effectiveness in rail operations – the role of long-term capex planning and major asset renewal and replacement", viewpoint, 2017 [30]

MAASiFiE, project funded by CEDR: "European MaaS roadmap 2025", 2017 [32]

UITP Action Point, "Connecting people and place – integrated mobility plans for sustainable cities", 2014 [33]

UITP Action Point, "Stakeholder collaboration on data in public transport", 2017 [34]

In Europe, General Data Protection Regulation (Regulation (EU) 2016/679) will enter into application on 25 May 2018, envisaging harmonization of data protection [35]

AAA Automotive, "What does it cost to own and operate a car?", 2016 [36]

Sochor, et al. "Travelers' motives for adopting a new, innovative travel service", 2016 [37]

MaaS Lab, UCL Energy Institute, "Londoners' attitudes towards car-ownership and Mobility-as-a-Service: impact assessment and opportunities that lie ahead", 2018 [38]

Arthur D. Little, "Integrated mobility platforms – how to win the customer in tomorrow's world of smart mobility", report, 2018 [39]

MaaS Alliance whitepaper, "Guidelines and recommendations to create the foundations for a thriving MaaS ecosystem", 2017 [40]

Arthur D. Little, "Strategic direction to address China's urban mobility challenges", 2014 [41]

Michelin Challenge Bibendum, "Launch innovative mobility to drive growth and urban well-being!", 2014 [44]

Arthur D. Little "Urban logistics – how to unlock value from last mile delivery for cities, transporters and retailers", 2015 [45]

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The Future of Mobility 3.0

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Arthur D. Little has been at the forefront of innovation since 1886. We are an acknowledged thought leader in linking strategy, innovation and transformation in technology-intensive and converging industries. We navigate our clients through changing business ecosystems to uncover new growth opportunities. We enable our clients to build innovation capabilities and transform their organizations.

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UITP

The International Association of Public Transport (UITP) is the international network for public transport authorities and operators, policy decision-makers, scientific institutes and the public transport supply and service industry and a passionate champion of sustainable urban mobility. It is the only worldwide network to bring together all public transport stakeholders and all sustainable transport modes with 1,500 members and 18,000 contact members from 96 countries with 16 offices across the globe. UITP is the global advocate of public transport and sustainable mobility, and the promoter of innovations in the sector.

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