



Voices on Infrastructure

Advancing urban transport infrastructure

July 2019





Table of contents

02 Introduction

03 News from the Global Infrastructure Initiative

04 The year of future transportation: An interview with Seoul Mayor Park Wonsoon

08 Debate: Will UAVs gain traction in urban delivery operations?

13 Declining bus ridership: Improving the efficiency of transit networks

17 The next frontier of public infrastructure: An interview with Deborah Flint, CEO of Los Angeles World Airports

20 Building the infrastructure for the future of mobility

24 Building self-sustaining public transport: An interview with William Sabandar, president director of MRT Jakarta

28 Preparing our cities for shared autonomous-vehicles

32 New mobility maps out a 21st-century course for transport infrastructure development

36 Setting course for a future of seamless mobility

40 Start me up: Where mobility investments are going

45 Four questions on the future of urban mobility

Introduction



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Welcome to the July 2019 issue of *Voices*, a collection of insights on **advancing urban transport infrastructure**. Transport is

experiencing a wave of global innovation, attracting some of the world's most ambitious entrepreneurs. Yet most metropolitan areas have not seen significant performance improvements in the safety, congestion, reliability, or net carbon emissions of their transport systems.

Moving the needle on these outcomes will likely rely on autonomy, sharing, electrification, connectivity, and many other emerging themes in our transport ecosystem. But it will also be critically shaped by infrastructure that is designed, planned, delivered, and operated with these trends in mind. As public- and private-sector leaders lay the groundwork for the future of mobility, how should they think differently about our roads, micromobility systems (such as walking, e-bikes, and e-scooters), subway and rail networks, and even air space?

This edition of *Voices* looks at how our cities' core infrastructure needs to evolve in lockstep with new mobility technologies and business models. It outlines a vision of seamless tech-enabled mobility; explores how cities worldwide are forging steps toward that vision; and discusses the implications of this future for our metros, bus networks, airports, and more. 

News from the Global Infrastructure Initiative



Tony Hansen

Director of the Global Infrastructure Initiative,
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Welcome to the July 2019 edition of *Voices*, exploring the theme of reshaping urban mobility. Over the past decade, the mobility sector has seen significant disruption, yet most metropolitan areas have experienced limited performance improvements, as measured by safety, congestion, reliability and maintenance, and net carbon emissions. Our insights investigate the difficulties of addressing these issues and what it will take to move the needle.

In this edition we have experimented with a new format, notably a debate on whether drones will capture a significant share of the urban delivery market. We welcome your thoughts and suggestions for future editions of *Voices*. Looking ahead, our September edition of *Voices* will focus on modular construction, and we plan to cover the topic of workforce and skills in our December issue.

The theme for our [sixth GII Summit](#) in Montréal in June 2020 will be the project of the future. Global industry trends — such as digitization, industrialization, vertical and horizontal consolidation, and rising technology investment — are poised to dramatically change all stages of the project life cycle. Participants will discuss how the project of the future will likely operate as a single production system, with technology integrated throughout the project lifecycle. Our program pillars will tackle fundamental industry challenges, including digital and analytics transformation, collaborative project delivery, leadership and workforce development, and future-proofing infrastructure. For more details, please visit our [Summit page](#).

Our 2019 GII roundtables are in full swing, having recently hosted roundtables in Madrid and London. In June, we cohosted an exclusive site visit to Montréal's Réseau express métropolitain with global institutional investor, Caisse de dépôt et placement du Québec (CDPQ). Visit our [roundtable](#) and [innovation site visit](#) pages to see past and future events.


We hope you enjoy this edition of *Voices*, and we invite you to share your thoughts on any of our GII programs. If you have comments or would like to subscribe a colleague to *Voices*, please contact us at info@giiconnect.com. 



Photo courtesy of Mayor Park Wonsoon

The year of future transportation:

An interview with Seoul Mayor Park Wonsoon

As Seoul's mayor seeks to bring transportation improvements to the city, he must carefully consider how to implement sustainable infrastructure and new technologies to best meet citizens' needs.



Park Wonsoon

Mayor
Seoul

Mobility of the future aims to enhance the convenience, reliability, and sustainability of transportation by harnessing new technologies such as the Internet of Things (IoT), automation, and artificial intelligence. But for such transformations to be successful, involved government leaders must identify both the needs of citizens and the vast potential of the ever-evolving technologies.

Seoul Mayor Park Wonsoon is familiar with this undertaking. Wonsoon, who has introduced several future mobility initiatives over the past eight years, named 2019 the Year of Seoul's Future Transportation. He spoke with McKinsey about his current and planned efforts to innovate the way citizens of Seoul move, including harnessing mobility technologies such as autonomous and connected cars.

McKinsey: *What do you see as the biggest transportation challenges that Seoul needs to resolve in the next ten years?*

Park Wonsoon: In January 2013, I vowed to transition Seoul from a car-centric city into a people-centric city.

The starting point for transforming Seoul into a people-centric city is improving areas closest to the day-to-day lives of citizens. I view our mandate for the next decade as twofold: first, meeting the complementary goals of creating a walkable community and enhancing the public interest in pedestrian space; second, tackling climate change issues, such as fine dust particles, while preserving the city's nature, history, and culture.

I have worked to make Seoul a city that respects the walking rights of all citizens by creating spaces such as Sinchon's pedestrian- and bike-only street, an exclusive zone of the street Yonsei-ro solely for public transportation, the child-friendly A.Ma. Zone safe street, the Seoul Trail and urban walking trails, and the Seoullo 7017 pedestrian path.

To combat fine dust particles surging to emergency levels, we are planning to limit old diesel vehicles on the roads and switch to green cars, including hydrobuses and electric vehicles. We also designated the area contained by Seoul's 700-year-old Fortress Wall as a Green Transport Promotion Zone—an area that prioritizes sustainable transport such as walking, biking, and electric vehicles. Higher-emission vehicles, such as old diesel cars, are barred from entering the zone. And we are establishing electric buses, pedestrian zones, and public transport facilities (such as a bicycle rental center) to encourage cleaner modes of transport.

McKinsey: *What are Seoul's primary key performance indicators for urban mobility?*

Wonsoon: Our approach to mobility is based on the rights of citizens and sustainability. Citizens want convenient, reliable, and diverse personal mobility choices, including bicycling, and they consider pedestrian right-of-way as a basic part of human dignity. Seoul is considering ways to improve citizens' quality of life in these ways and create a city that empowers people and respects their safety and civic convenience.

For example, we are currently carrying out the Special Smart City Zones project in two autonomous districts in Seoul: Seongdong-gu and Yangcheon-gu.¹ In Seongdong-gu, smart crosswalks have sensors for detecting movement that trigger flickering lights along the crosswalk to help draw pedestrians' attention to the safety line and traffic signals. And drivers will see the lighted crosswalk from a distance, giving them more time to slow down. In Yangcheon-gu, IoT services—such as one service that uses artificial intelligence to reserve parking spaces for people with disabilities—have been launched to bring on-the-ground services directly to where people actually need them.

Our subindicators thus include the number of traffic fatalities, public bicycles, car-free streets, and secured parking lots in residential areas; public transit user satisfaction; and air quality.

McKinsey: *How are Seoul's leaders using technology to manage and improve urban mobility?*

Wonsoo: Technology has been a priority in Seoul's government since the 1960s; thus, it isn't surprising that city leaders are committed to creating smart transportation.

As part of our transportation initiative, we are installing 50,000 IoT sensors across the entire city. This initiative includes a parking system where parking availability can be checked in real time through IoT technology, and a taxi service that connects the driver and the passenger by predicting real-time taxi demand through artificial intelligence. We are also building an integrated control center for processing administrative services such as toll collection, payment, and management. By harnessing smart security cameras and deep learning, we will automate simple tasks that previously relied on the human eye, thus increasing service efficiency.

On another note, Seoul is using technology to transition to an environmentally friendly and sustainable transport system. For example, the city is making efforts to manage transport demand and improve air quality by managing the total traffic volume and using information and communications technology to restrict high-emission vehicles.

The city will enhance the level of services by applying connected-car technology. We are also planning to launch a connected-car pilot on 1,600 city buses this October and develop the world's first all-in-one platform to create a safer transportation culture. The all-in-one platform integrates the individual devices that had been installed on buses for operation management,

electronic traffic cards, driving history records, 5G capability, vehicle-to-everything (V2X) connectivity,² and advanced driver-assistance systems. The platform provides data about unexpected events on the road, including jaywalkers, improperly passing cars, and accidents related to traffic signals and crosswalks.

McKinsey: *What concrete preparations are Seoul's leaders making in line with the deployment of autonomous cars?*

Wonsoo: The biggest change in urban life for the future smart city is probably going to be autonomous driving. Autonomous driving will be a trigger point and a catalyst in transforming not only the physical landscape of the city but how people, technology, and capital are connected.

This month, we will complete the world's first test bed for 5G convergence with autonomous driving at Sangam Digital Media City. It is the only test site in the world that supports autonomous driving with 5G and V2X technology on public roads. We will run 5G network-based driverless buses, and various start-ups will test their technologies here.

We have applied to register this area as a "specialized complex for automotive driving and 5G smart city" with South Korea's Ministry of Land, Infrastructure and Transport, and we plan to apply for regulatory exemptions that will dedicate this area for testing autonomous driving. We expect the site to improve the competitiveness of domestic companies involved in autonomous driving, and we believe that public-private partnerships from the testing stage are important for advancing user-centric public services.

McKinsey: *How are Seoul's leaders encouraging citizens to participate in improving urban mobility?*

Wonsoo: To develop information and communications technology-based services, we have launched the "public-private partnership

for a smart city” project where various players—including citizens, businesses, and experts—can collaborate. This project harnesses an open platform to allow these players to brainstorm innovative ideas and solutions, from business development to implementation.

Ultimately, innovation in urban mobility must address the changes to citizens’ lives that will come in the future. For the past eight years, the Seoul Metropolitan Government has come up with new, exciting solutions through experiments together with its citizens in urban centers and on the streets. Now, at this turning point, Seoul will once again seek solutions together with its citizens, promoting cooperation not only with other districts but with cities around the world. ■

¹ “Seongdong and Yangcheon to become the first Special Smart City Zones in Seoul,” Seoul Metropolitan Government, January 31, 2019, english.seoul.go.kr.

² Vehicle-to-everything (V2X) technology wirelessly enables a vehicle to exchange data with its surroundings, including infrastructure and other vehicles.



Debate: Will delivery UAVs scale by 2030?

Motion: Unmanned aerial vehicles (UAVs) will gain traction and claim a significant share (1 to 5 percent) of urban deliveries by 2030.

For:



Will Hetzler

Cofounder
Zipline International

Zipline is a drone-delivery company that supplies essential medical products to underserved communities.

Against:



Carlo Ratti

Director, SENSEable City Lab;
Professor of Urban Technologies
and Planning, MIT

The SENSEable City Lab is a research initiative at MIT that studies and anticipates the impact of technology on urban residents and environments.

UAVs, commonly known as drones, are a hot topic of debate. Will they become ubiquitous? How can safety concerns be addressed? How should they be regulated? McKinsey asked two professionals close to the issue to weigh in on whether they believe UAVs will gain traction and claim a significant share of urban deliveries by 2030. Below, Will Hetzler and Carlo Ratti share their initial arguments and then respond to each other's claims.

Carlo Ratti opening statement

Flying vehicles have long tantalized our imagination, as evidenced by films such as *Metropolis* and *Blade Runner* and the cartoon series *The Jetsons*. Yet, I think they will stay in our imagination for some time to come. In lightweight applications—for example, sensing and small parcels—UAVs can indeed play a big role in sparsely populated areas and in cities. But there are various physical and practical reasons why our city skies will not be filled with delivery UAVs anytime soon.

Let's consider the physics. A huge amount of energy is required to lift a heavy object vertically into the air, creating a vast amount of noise and air disturbance. In dense cities such as New York, an overwhelming percentage of all goods is delivered via trucks. Each day, approximately 25,000 delivery trucks and commercial vehicles move into, around, and out of Manhattan.¹ If even just 5 percent of those vehicles were replaced by drones, that would mean 1,250 UAVs—the largest helicopters—dotting the skies.

There is also the issue of safety. Even with the new lithium-metal batteries, which have twice the energy density of—and more stable performance than—conventional lithium-ion batteries, moving substantial quantities of goods overhead presents a recurring safety hazard. Modern trucks may be noisy, but a dead battery or a broken rotor blade in a delivery drone used for urban deliveries could cause it to fall onto a densely populated area.

Even if we used UAVs only for lightweight deliveries, thus allowing the use of smaller drones that pose a

less significant safety risk, we would find ourselves with tens of thousands of vehicles in the sky. How could we ensure these flying objects were protected from hackers, terrorists, and other criminals? How might air traffic control systems safely coordinate their intersecting journeys?

Of course, these challenges do not signal the end outright of new delivery options or UAVs. However, in densely populated cities, the challenge of achieving faster and more efficient last-mile deliveries could probably be better fixed in other ways by rotors planted firmly on the ground. For these reasons, I do not believe UAVs will gain traction and claim a significant share of urban deliveries by 2030.

Will Hetzler opening statement

Drones provide a unique combination of flexibility, efficiency, and speed. Logistics systems need these capabilities to meet growing demand for residential deliveries as consumer expectations set by online shopping spread to sectors outside retail, such as healthcare. This demand will lead to drones being used for a significant share of urban deliveries by 2030.

Drones' advantage in the United States is strongest for business-to-consumer (B2C) deliveries, such as healthcare products, small online purchases, and food. Traditional ground transportation is optimized for business-to-business (B2B) deliveries and fails to adequately serve many new B2C business models recently enabled by technology. B2C deliveries are already a majority of the package volume in the United States and are growing faster than B2B deliveries, making the opportunity for drones significant.² Drones can meet the demand of consumers for faster delivery and also give consumers more control over the time and location of delivery.

Due to technical and regulatory constraints, drones are best suited to small-package delivery. Barring a breakthrough in energy storage, this

will remain true in 2030. While this might be viewed as a limitation, B2C deliveries trend small. For example, 86 percent of the items that Amazon ships weigh less than five pounds.³ And the demand for such small-package delivery is increasing rapidly.⁴

Today, drones most easily deliver to single-occupancy, detached structures. While this type of development is often associated with suburban and rural areas, single-family, detached homes make up approximately 60 percent of the housing units in America's largest metropolitan areas.⁵ Consequently, while drone delivery may be impractical in Manhattan, most US metropolitan areas are readily serviceable with current drone technology. As technology continues to improve over the coming decade, the proportion of urban addresses that are serviceable by drones will only increase.

Carlo Ratti rebuttal

We both agree that drones are not likely to work in the densest urban areas. And we also agree that they could indeed play a role in rural areas and in places where the road infrastructure is not fully developed—especially for time-sensitive or medical deliveries. However, we disagree about the ability to scale in urban areas.

To Will's point that drones combine flexibility, efficiency, and speed, I would argue that safety and reliability are more important than any of these factors. And there is a simple reason why drones are much less reliable and safe than any vehicle on wheels: weather.

Most of us have experienced commercial flights being canceled because of weather. A common thunderstorm can ground a light aircraft with a mass that's three or four orders of magnitude larger than a drone. Air movement of just a few meters per second could be enough to send small drones bumping into buildings or falling from the sky.

In China, drones are used in remote rural locations to ship parcels. Despite having some of the loosest regulations for UAVs in the world, the local civil aviation authority does not allow drones to fly under circumstances in which the use of a car or even a bike would not be questioned, including through rain, light wind, and darkness.⁶ While it's possible that new sensors might combat the darkness issue in the future, the problems with rain and wind are based on physics and therefore unlikely to be resolved.

How will drones perform in metropolitan areas such as Vancouver, Canada, and Amazon's home, Seattle, both respectively known as "Rain City"? The first week of May this year in Boston was marked by near-constant rain—what would have happened to time-sensitive deliveries? Such unreliable conditions make it unlikely that we will be able to scale drone delivery in the near future.

While a majority of the items Amazon ships weigh less than five pounds, as Will points out, typically hundreds or even thousands of such small parcels are packed together on the same truck and delivered with clear efficiencies of scale. Meanwhile, lightweight drones are unlikely to be able to transport much more weight than one or two pairs of shoes, thus forcing them to return to the base to collect the next parcel. As a result, the total number of required trips would need to be multiplied by two or three orders of magnitude, generating congestion in the skies.⁷ Not to mention, these small drones would be much more sensitive to even mildly adverse weather. Such conditions would hinder speed and efficiency and make it difficult to scale.⁸

I believe UAVs indeed offer interesting solutions for mobility and logistics in the future—especially for remote locations. But I am still skeptical about their ability to scale in cities.

Will Hetzler rebuttal

It's easy to agree on what the future of drones in cities is not. Large drones capable of transporting a full truckload are unlikely to make many urban deliveries within the next ten years. And drones of any size may be impractical delivery vehicles in the densest urban environments in this time frame. However, there is a real opportunity for urban drone delivery of small packages in the vast majority of cities.

The technical capability exists today for residents of most cities to routinely receive deliveries by drone, and a decade is plenty of time for new technology to transform the industry. For an example of how quickly urban transportation can change, consider ridesharing, which has only existed for around ten years but now accounts for significantly more annual rides than taxis.⁹

As Carlo notes, the safety of urban drone delivery is an important topic, and many questions must be answered before urban drone delivery can reach scale. For example, cybersecurity is a concern for drones, just as it is for all transportation technologies, including in cars and trucks. How to coordinate drone traffic is another concern. Fortunately, academics, regulators, and private industry have started working on these issues and are making fast progress.¹⁰

It is important to note that delivery drones differ dramatically from the recreational drones flown by hobbyists. Performance standards and rigorous testing ensure that delivery drone designs are safe. I believe the FAA would never allow commercial operation of a delivery drone that could fall out of the sky due to a dead battery or broken rotor blade. The aviation industry has a long-standing practice of designing redundancy into safety-critical systems, and commercial drone companies use this same approach. Delivery drones are also already safely operating in heavy rain and turbulent winds greater than 60 miles per hour.

In the United States, the FAA certifies drone delivery operators under the same part of the Code of Federal Regulations as manned air carriers that provide commuter, on-demand, and cargo flights, commonly referred to as "Part 135 operators."¹¹ Consequently, drone delivery operators are held to equivalent safety standards. While it's difficult to directly compare safety statistics for different transportation modes, ground transportation has significantly higher accident rates than Part 135 operators and roughly double the number of accidents involving fatalities.

While drones will deliver pizzas and small online purchases in the near future, the primary social benefit of drone delivery is in healthcare. Drone



delivery has the potential to affordably provide every human on Earth with near-instant access to vital medical supplies, regardless of whether they live in a city or a rural community. Such delivery will reduce the logistical burden of managing chronic health conditions, enable more home-based acute care, and avert hospitalizations and trips to the emergency room. This is a vision for drone delivery that excites me, and it's a future that our team at Zipline is working to build. ■

¹ "Off-Hour Deliveries (OHD) Program," New York City Department of Transportation, accessed May 21, 2019, www1.nyc.gov.

² *Strong today: Creating our tomorrow*, UPS 2018 annual report, investors.ups.com.

³ Jeff Bezos, "Amazon's Jeff Bezos Looks to the Future," interview by Charlie Rose, 60 Minutes, CBS, December 1, 2013, transcript, 6.

⁴ *Strong today: Creating our tomorrow*, investors.ups.com.

⁵ U.S. Census Bureau, American housing survey, general housing data, census.gov. All occupied units for 43 listed metropolitan areas.

⁶ "China is on the fast track to drone deliveries," *Bloomberg*, July 3, 2018, bloomberg.com.

⁷ Drones' lift force is generated by moving large volumes of air downward, which means they cannot fly on the top of one another (unless at large distances). This effectively restricts the use of space as it relates to vertical dimensions and could exacerbate congestion issues in the future.

⁸ A standard last-mile delivery truck can carry a volume of approximately 12 square meters with a ground footprint of approximately 10 square meters. Amazon's large, standard-size truck has the following specs: maximum weight of less than 20 pounds and maximum dimensions of 18 x 14 x 8 inches. This means that the load of just one truck would need at least 380 drones to be delivered—and more than 1,000 if parcels are smaller (closer to 5 pounds).

⁹ Johana Bhuiyan, "Ride-hail apps like Uber and Lyft generated 65 percent more rides than taxis did in New York in 2017," *Recode*, March 15, 2018, recode.net.

¹⁰ For instance, the FAA and NASA are collaborating with the aviation industry to develop unmanned aircraft system traffic management (UTM) to assist with coordinating the high volume of advanced drone operations that will come in the near future.

¹¹ The full definition of 14 CFR Part 135 operations is complex but covers the following: air ambulance and commercial helicopter operations, on-demand cargo flights on airplanes with a maximum payload capacity of 7,500 pounds, air taxi and charter flights on airplanes with seats for a maximum of 30 passengers, and scheduled commuter flights on airplanes with seats for a maximum of nine passengers.

¹¹ The full definition of 14 CFR Part 135 operations is complex but covers the following: air ambulance and commercial helicopter operations, on-demand cargo flights on airplanes with a maximum payload capacity of 7,500 pounds, air taxi and charter flights on airplanes with seats for a maximum of 30 passengers, and scheduled commuter flights on airplanes with seats for a maximum of nine passengers.

¹² The most recent five-year period for which federal safety statistics are publicly available.

¹³ *Traffic safety facts: A compilation of motor vehicle crash data from the fatality analysis reporting system and the general estimates system*, U.S. Department of Transportation, 2016, crashstats.nhtsa.dot.gov.

¹⁴ Figures are based on US civil aviation accident statistics from 2012 to 2016, National Transportation Safety Board, ntsb.gov; and US air carrier traffic statistics from 2012 to 2016, Bureau of Transportation Statistics, bts.gov.

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Declining bus ridership: Improving the efficiency of transit networks

Transport authorities are navigating lower public-transit ridership, declining air quality, and growing financial pressures. Integrating bus networks into the broader urban infrastructure is key.



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Urban commuters—especially those in developed economies—have more transportation options than ever before, from private cars to rideshares to public transit. Unfortunately, largely due to low fuel prices and the relative affordability of private (and private hire) vehicles, every year more of these commuters are abandoning public transit. Bus ridership in particular has seen a precipitous decline over the past decade. And with more private vehicles on the road, congestion increases, which slows bus travel times even further and creates a vicious cycle of further ridership declines. From 2010 to 2016, for example, traffic congestion rose 30 percent in New York City, 14 percent in London, and 9 percent in both Beijing and Paris.¹

In the densest urban areas, more environmentally friendly micromobility options, such as bicycles and scooters, may also be contributing to the decline in bus ridership. In London, bicycle trips increased by approximately 30 percent from 2010 to 2017.²

A decline in bus ridership is a problem because buses are critically important in cities around the world—from Seattle to Singapore. They have the potential to ease both congestion and pollution, they provide transport to jobs from low-income or rural communities that tend to be underserved by intra-city trains, and they are often the primary transport option for people with disabilities.

As the number of bus riders continues to fall, so too does the revenue municipalities have available to improve, or even maintain, quality of service. The resulting “spiral of decline” threatens the viability of buses and leaves transit authorities struggling to work out how to generate the revenues required to maintain public-transport services, let alone make meaningful investments in sustainable urban mobility. Indeed, in many cities it is unclear how transit authorities and city leaders will finance their pledges to address air quality concerns and reduce the carbon footprint of public transit by

shifting to electric buses—especially given their higher up-front cost.³

There are bright spots in some parts of the world. For example, Paris has heavily supported bus development and has coordinated bus networks to fill in “cold spots” on their underground and rail networks, particularly in the outlying suburbs. In addition, Singapore’s transport authority is actively pushing a modal shift from cars to buses, swapping out its single-level fleet with double-deckers to better cope with expected increases in ridership. Buses are also gradually getting cleaner: The number of electric buses procured in Europe more than doubled in 2017 compared to 2016, and 17 percent of China’s total bus fleet is electric.

Reducing congestion, facilitating a modal shift to public transportation, and addressing environmental concerns are major challenges for transit authorities and city leaders alike. Our research shows that cities can improve both sustainability and the quality of urban mobility by improving the efficiency of existing transportation networks, starting with buses.

Buses’ role in making existing networks as efficient as possible

Cities can improve the efficiency of transit networks by providing multiple, viable, and complementary modes of transport, and buses play an important role in this endeavor. Compared with metro or rail systems, bus networks can ramp up service—serving more people or new and underserved areas—rapidly and without much additional infrastructure. A 2019 TransitCenter study, which looked at 2018 ridership data from transit agencies across the United States, found that reorienting bus networks to meet demand is demonstrably linked with increasing ridership.⁴

An important aspect of making buses attractive is striving for transit time that is comparable to private cars. Stockholm’s PRIBUSS system, for

instance, gives priority to buses at traffic lights to help keep things moving. Cities can also implement all-door boarding and off-board payment to expedite journeys. And sending real-time updates and alerts to passengers can make taking the bus more predictable and user friendly. Furthermore, some lanes or streets can be designated as bus only.

Lowering the cost of buses relative to private cars is also important. One approach to consider is introducing congestion charging zones, which are priced to reflect demand on road space and the level of pollution a vehicle generates. While congestion zones are often contentious and politicized decisions, such strategies have proven successful in cities such as Milan, Singapore, and Stockholm. Earlier this year, lawmakers in New York City agreed on a plan to implement a congestion tax in Manhattan, which will be the first in the United States.

Integrate bus networks into broader urban infrastructure

In addition to incentivizing bus ridership over private car use, transport authorities should take greater steps to integrate bus networks with overall city infrastructure, particularly as the urban environment responds to new mobility trends such as electrification and autonomy, for example:

- Supporting the next generation of bus services by building a network that combines an electrified bus rapid transit (BRT) system with smaller, on-demand, zero-emissions vehicles to deliver riders to BRT hubs.
- Reducing the number of delivery vehicles on the road by utilizing public infrastructure, perhaps by introducing delivery lockers for commuters at metro stations; or creating a road pricing or regulatory environment that incentivizes night deliveries, making greater use of times when the road space is underutilized.

- Creating opportunities for affordable housing within transit hubs. Quieter, cleaner, electric buses could lead to residential units being developed above existing bus depots, for example. If this were achieved, it would address multiple objectives—for example, Transport for London has strategic objectives to increase affordable housing as well as provide transport services. Housing and transportation should be complementary, working to increase access and convenience for all citizens.
- Striving to better understand consumer preferences and user journeys to help shift behavior at critical decision points. While it is intuitive that customers prioritize speed, price points, and a comfortable experience in their transit decisions, city leaders would benefit from better understanding how these priorities differ based on time of day, day of week, and location for different customer segments within a city.

As public transport authorities consider options to improve the quality of life for citizens, they face a series of financial and political constraints. Simultaneously, they seek to improve the relative cost and journey time of public transport compared with private and for-hire vehicles, expedite the arrival of zero-emissions buses, and balance the books—all at a time when bus ridership and associated revenue are falling.

Two major levers that could help achieve this—emissions-linked congestion charging and reducing the road space available for private vehicles—require significant political and financial capital. As city leaders determine their willingness to impose such restrictions, transport authorities are thinking more creatively about other levers they can utilize. For example, how can the growth in power demand across the city, and associated private-sector investment, be used to roll out power for electric

buses? Furthermore, how can authorities work with logistics companies to consolidate parcel delivery to citizens and influence the time of day business deliveries occur?



Mobility is evolving faster than nearly any other part of the urban built environment. Even as cutting-edge technologies such as air-mobility and autonomy take shape, city leaders must begin to consider how to better use the assets they have now to solve financial, environmental, and other challenges on the horizon. ■

¹ Eric Hannon, Stefan Knupfer, Sebastian Stern, and Jan Tijs Nijssen, “The road to seamless urban mobility,” McKinsey Quarterly, January 2019, McKinsey.com.

² Travel in London: Report 11, Transport for London, 2018, content.tfl.gov.uk.

³ Alister Doyle, “Twelve major world cities agree to buy zero-emissions buses from 2025,” Independent, October 23, 2017, independent.co.uk.

⁴ “There’s a reason transit ridership is rising in these 7 cities,” TransitCenter, February 27, 2019, transitcenter.org.

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Photo courtesy of Los Angeles World Airports

The next frontier of public infrastructure:

An interview with Deborah Flint, CEO of Los Angeles World Airports

Los Angeles International Airport has undertaken one of the largest public works projects in California's history. A focus on public-private partnerships has helped keep things on track.



Deborah Flint

CEO
Los Angeles World Airports

As the fourth-busiest airport in the world and the second-busiest in the United States, Los Angeles International Airport (LAX) has long had a reputation for traffic congestion. However, in 2019 Los Angeles World Airports (LAWA) broke ground on the Landside Access Modernization Program. This massive \$5.5 billion renovation encompasses multiple projects to deliver an electric train system (the Automated People Mover, or APM), a consolidated rental car facility, roadway and utilities improvements, and improved digital integration. Construction of all elements is currently underway—with completion expected in 2023.

In this interview, Deborah Flint, CEO of LAWA, explains the challenges she has faced taking on several concurrent major projects, how her team has approached key public–private partnerships, and how she envisions the future of airports.

McKinsey: *To begin, what effects will the LAX Landside Access Modernization Program (LAMP) have on people’s daily lives?*

Deborah Flint: It’s a little tongue in cheek, of course, but we believe our work here will save relationships. Today, when someone asks you to pick them up at LAX, it’s a real test of how much you care about that person. Getting in and around the central terminal area by car can take anywhere from 15 to 50 minutes.

The LAMP, and the APM specifically, will create seamless transportation access to the airport when completed in 2023. People will be able to take the train to the central terminal area from new parking facilities and a rent-a-car facility, as well as finally be able to connect to the regional light rail system, depending on their needs. The longest of these journeys will take just 10 minutes. This will significantly decrease vehicle congestion and free up important curbside boarding areas.

McKinsey: *What sort of problems have you run into, and what have you done to solve them?*

Flint: I learned early in my leadership that we operated in silos across the airport. Each department was essentially establishing its own objectives, but there was no common vision. An outcomes-based process for allocating capital helped us knock down those silos. We no longer just look at what projects the airport wants to do and then validate that they’re needed. Now we work together to identify objectives and deploy capital in a way that will achieve those objectives, delineate the expected performance, and focus our investments. Security, community, sustainability—all of these must be integrated into the outcome and performance expected from capital investments.

McKinsey: *Is there advice you would share with other leaders taking on major modernization initiatives and capital improvement projects?*

Flint: I would advise others to focus on performance metrics and data analytics early in the planning stage of a project or a program, or in a budget cycle, to help drive major investment decisions.

It is not easy. This is certainly a journey. For many public agencies, obtaining baseline data is a challenge. Even for those of us that have project management systems, getting that data and making it meaningful and consistent is still a fundamental challenge. Last year, we began a data center of excellence to understand the data we have to make better decisions. We now collect data around our facility, looking at things such as aircraft timing and operations in the terminals. Our facilities team has been able to better deploy staff resources, and our quality of service has increased.

McKinsey: *The LAMP comprises several major projects, which are generally very complex to execute on time. What are you doing to keep the program on track?*

Flint: We know the stats for delivering even a single major project—they don’t bode well. At the end of the day, keeping projects on schedule is a shared responsibility of the owner and developer. There’s

an availability payment, so the developer has a strong incentive to open the project on time. But we also want them to do this successfully.

To facilitate the permitting process, for example, we invest in partnerships with city agencies so that the requisite permits are received in a timely manner. Even when there are gray areas of responsibility, LAWA has taken a vested interest in resolving any permitting hiccups between the developer or the agencies, rather than stepping back.

McKinsey: *How did you think about public-private partnerships (PPPs) in developing the LAMP—and how do you see your partnerships evolving in the coming years?*

Flint: There's room for PPPs to be successful if proper analysis is done at the earliest stages of a project, and if the owner is clear about what's important. During selection, we listened very carefully to what the industry said was tenable and realistic. Owners and developers are going to have to share risk and responsibility for PPPs to flourish in the US.

We began the LAMP by evaluating whether PPPs were the right approach for us. As a result, we spent a lot of time assessing delivery options early on, and then considering why a particular PPP model—design, build, finance, operate, and maintain—made the most sense for the APM and the Consolidated Rent-A-Car (ConRAC) Facility, for example. I think the future of public infrastructure relies on life cycle asset management approaches, and that's essentially what we entered into. It's not a concessions model. It's a model where we have aligned interests with the developers for the next 30 or so years.

For the ConRAC we decided that future-proofing was our most important element. We're incorporating over 16,000 parking spaces in

an era when mobility is changing rapidly. We recognized that we're taking some risk there and asked the private sector to help us mitigate that risk—and they did. The team we selected designed the facility not only to allow future flexibility but also to reduce the footprint and return almost 20 percent of the site back to us for future uses.

McKinsey: *How do you see technology and tech-enabled mobility changing the future of airports?*

Flint: The passenger of today expects a digitally connected journey, whether it's prebooking, ordering food and beverages, or the delivery of retail goods. Biometrics are a game-changer. For example, this past year we offered the option of a fully tokenless international journey, where passengers can use their face as their boarding pass for a faster, easier airport experience. We're thinking about digital every step of the way to ensure that the experience is seamlessly connected—you're not switching from one app to another.

Mobility is changing so quickly, whether it's autonomous, congestion pricing, or micromobility. I do believe we now need an established team of mobility experts who think exclusively about how we can increase efficiency getting to and around the airport. That is a big part of the future for airports. ■

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Building the infrastructure for the future of mobility

Our road and rail infrastructure is not ready for the future of mobility. Owners and operators should act now or risk being left behind.



Carsten Lotz

Partner, Stuttgart
McKinsey & Company

When it comes to infrastructure, the developed world is running on a hamster wheel. In Europe, we estimate that governments spend 50 to 70 percent of their transportation infrastructure budget on maintaining or replacing aging existing systems. These upgrades are especially complicated and expensive as running traffic needs to be maintained, sometimes requiring the construction of provisional solutions, and a variety of stakeholder interests—those of infrastructure users, neighbors, developers, and investors—need to be addressed.

Furthermore, the vast majority of existing infrastructure is not ready for the future of mobility. Automation, connectivity, electrification, and shared mobility are upon us, but the road and rail infrastructure requirements to facilitate these technologies are often not considered when rebuilding individual projects. In short, there exists no integrated vision of how to equip the infrastructure of the future. To build one, we need to answer a long list of questions, such as how electricity supply will be provided to fast-charging stations on motorways, how we will provide connectivity for autonomous driving, and how we manage the integration of old and new train control systems.

To prepare for the future of mobility, operators need to leap off the revolving wheel of repair. They need to develop an understanding of the desired end state and then take a hard look at their operating models. And they need to optimize current costs, adjust financing mechanisms, develop new competencies, collaborate with regulators to facilitate policy changes, cooperate with other infrastructure stakeholders, and transform their management models to break the constant repair and slow technological cycles. Those who start now will move to a new, modern mobility system with a better user experience faster, and at a lower cost, than those who wait.

What owners and operators need to do now

Operators need to start by developing a few likely scenarios describing possible future needs. These scenarios must consider upcoming technological developments as well as varying user preferences. They also should highlight the expected socioeconomic benefits and outline an approach to maximize them. (For more on McKinsey's research into modeling city mobility strategies, see *The road to seamless urban mobility*.)

Once a target scenario is established, operators can develop a road map for turning it into reality. This road map needs to offer details on resources—including required R&D—and potential financing options, as well as implementation time with necessary regulatory approval and testing periods. In plans for both new and rebuilt infrastructure, the map must account the needs of today and the future—for example, ducts for fiber and power cables to enable electric-car charging stations.

The target scenario will anchor operators' day-to-day operations. As conditions and the speed of technological development change over time, operators should build regular updates to the road map into their workflow to ensure they maintain their trajectory toward the target scenario.

Optimize costs and adjust financing mechanisms

Two methods are available for infrastructure owners to secure the capital needed to prepare for the future of mobility: cutting costs, and rethinking traditional financing mechanisms. On the cost-cutting front, procurement is often ripe for cost optimization. Current, drawn-out processes tend to involve months or even years of analysis, tendering, respecification, contracting, and deployment. By bundling smaller projects, defining functional specifications, and reworking contracts for performance, operators could expedite the process and significantly improve cost efficiency.

Additionally, operators and regulators need to rethink traditional financing mechanisms that may have served well in the past but cannot support the required transformation of the system. For instance, instead of having separate financing regimes and incentive mechanisms for capital and operating expenditures, they could take an integrated view—which can create greater incentive to invest up front to save money in the long run. Given the long-term, system-wide view needed, operators—particularly public entities—could abandon their yearly budgets in favor of securing multiyear financing. And this system-wide view should also inform replacement decisions, rather than relying solely on technical lifetime and economic depreciation rules.

Develop new competencies and processes

Adding future-oriented features—such as embedded sensors—to new and rebuilt infrastructure will enable autonomous vehicles and smart traffic-control systems, among other technologies, in the coming years. However, these features are not reflected in most operators' current planning and investment cycles. Today, operators tend to plan on a project-by-project basis, backed by a relatively static regulatory framework of technologies that are already approved, widely available, and easily deployed.

Preparing for both faster development cycles and the rollout of various integrated platforms will require operators to acquire new competencies in planning, maintenance, and operations. To acquire these new competencies fast, operators can engage in partnerships with nontraditional technology suppliers. They may also consider building a separate business unit to bypass standard company processes. Norway has established a separate road administration to speed up cost-efficient development and construction of selected highways, effectively creating a state-owned start-up for infrastructure innovation.

Collaborate with regulators to facilitate policy changes

As technology pushes mobility forward, it will be crucial to ensure proper regulations are in place to facilitate progress. In addition to essential safety tests and approvals, regulations can take a decade or more to design and implement, while innovation cycles can upend industries in under a year, so most regulations are already far behind where they need to be. We anticipate that autonomous-car technology will be ready in 2023, but regulation modifications will take an additional five to seven years—meaning autonomous cars won't be fully integrated into the transport system until 2030.¹

Operators will therefore need to work with regulators to adapt approval processes and help keep pace with accelerated technology development. Operators can also collaborate with regulators in thinking about how they build up *their own* new competencies, working together with them to define future regimes.

Cooperate with other infrastructure stakeholders

Finally, each new technology will come with costs and benefits to a variety of stakeholders, including infrastructure users, infrastructure operators, regulators, and financing bodies. As such, each of these stakeholders brings different perspectives to how to prepare infrastructure for the future of mobility. For example, railway network operators can benefit from fewer signals and less physical equipment on the track, but they need to balance their approach with the cost of refitting their train control units.

To minimize cost and maximize the benefits of new technologies, an integrated perspective on cost, benefits, and speed to implementation is necessary. Transport infrastructure operators—as a kind of natural monopoly—will be expected to orchestrate this process. They will also be

expected to create transparency on socioeconomic questions, such as how to distribute the cost of new technologies between different users, and how to balance opportunities for more traffic with noise reduction requirements for neighbors.

Transform the management model

This elevated responsibility requires a new management model for infrastructure operators. Today's planning horizons of 30 years and more need to be complemented by much shorter reviews for new technologies. Regional allocation of responsibility that served well for maintenance and even newly built infrastructure should be complemented by a central responsibility for the technical platforms of the future. Interdependencies of vehicles and infrastructure will grow, and so integrating users into strategy development and planning will be crucial. Finally, owners will need to think in terms of scenarios and options to create future-proof infrastructure. While almost anyone can drive on a road, the wrong traffic control system or sensors might quickly prove to be a futile investment.



Developing competencies, rearranging balance sheets, updating processes—the future of mobility presents many challenges, but it is inevitable. As such, operators can look at this transformation as an opportunity, and the cost of waiting to get started is huge. By adapting and laying the groundwork now, operators can avoid a mountain of expensive retrofitting and alleviate stakeholder distress across the spectrum. ■

¹ Sven Beiker, Garrett Bray, Alexander Brotschi, Gregor Eckhard, Paul Gao, Mingyu Guan, Russell Hensley, Hans-Werner Kaas, Dominic Kohler, Detlev Mohr, Timo Möller, Nicolai Müller, *Automotive revolution—perspective towards 2030*, January 2016, McKinsey.com.



Photo courtesy of MRT Jakarta

Building self-sustaining public transport: An interview with William Sabandar, president director of MRT Jakarta

Jakarta's flagship rapid-transit project has proven successful within its first year. MRT's director envisions a total of 230 kilometers of railway alleviating some of the world's worst congestion.



Rajat Agarwal

Associate partner
McKinsey & Company



William Sabandar

President director
Mass Rapid Transit (MRT)
Jakarta

As the largest economy in Southeast Asia, Indonesia has seen robust economic growth over the past decade, and one impact of this growth has been an increased number of private vehicles on the road. Congestion in the capital city of Jakarta is particularly bad, resulting in some of the world's worst traffic.

Mass Rapid Transit (MRT) Jakarta was established in 2008 with plans to invest 600 trillion rupiah (\$43 billion) in a train line that connects the corners of the city to its center.¹ In March 2019, the first transit line of Jakarta MRT, which covers 16 kilometers from Lebak Bulus to Bundaran Hotel Indonesia, opened to the public. Subsequent phases are planned in the coming years.

In this interview, William Sabandar, president director of MRT Jakarta, talks with associate partner Rajat Agarwal about the early stages of the project; the company's approach to financing and nonfare revenue; the importance of integrated cashless systems; and the vision for public transit in Jakarta.

McKinsey: *How did MRT Jakarta get the project off the ground?*

William Sabandar: MRT Jakarta was founded in 2008, and we broke ground five years later. In the interim, we faced the challenge of building confidence among people—residents, investors, stakeholders—that the project would even happen. We had to work hard to convince people that public transport in Jakarta can be reliable and that it can help develop a new landscape for the city. The company's vision is not just about infrastructure or building railways; it's about promoting public mobility and, by doing so, improving quality of life.

That's why MRT Jakarta is focused on three missions: promoting urban renewal, achieving operational excellence, and building a world-class company. We're already seeing the areas along the first MRT line changing, demonstrating excellence

during both construction and operation. During the first month, for example, the reliability of the train operations was 99.82 percent. And we did it all with accountability, good governance, and great people.

Now that people have seen this first line, the confidence is quite high. MRT is seen as something that's for everybody—not just for people who normally use public transport, but also for people who normally use personal cars. We're developing momentum to move to the next level.

McKinsey: *How did you finance the project?*

Sabandar: For the first phase of 16 kilometers, we secured a loan from the Japan International Cooperation Agency (JICA) of 17 trillion rupiah. So it's a long-term commitment between the government of Indonesia and the government of Japan. The second phase, which we hope to complete in 2024, will continue 8.2 kilometers north from Bundaran Hotel Indonesia to Kota Tua—that is also financed through JICA. We will likely need 22.5 trillion rupiah to finance phase two.

The third phase is the east–west rail, which will be 31 kilometers, from Kalideres to Ujung Menteng. We may work with JICA again but we're also looking into other innovative financing mechanisms, such as public–private partnerships. If those are successful, they could form a model for future phases.

McKinsey: *How has the public responded to the first line?*

Sabandar: It's gone very well. Before opening, we set a target of 65,000 passengers per day. On the first day, we got 72,000 passengers. In April, the average ridership was 82,500 passengers per day. The current vision is to exceed 100,000 per day on the first line by the end of 2019.

To ensure we priced rides correctly, we did a consumer preferences survey and found that less

than 10 percent of customers are price-sensitive; the rest are more concerned with reliability, convenience, and connectivity. Still, we offered a 50 percent discount for the first six weeks, which was a period of learning for our passengers. The queues were long at first, as people learned to use the ticket vending machines. We stationed additional staff and volunteers to help teach people how to use the system. It evened out after about a month. Now, we see the types of ridership behaviors you see in, for example, Japan or Singapore—being on time, standing in the queue, and demonstrating proper etiquette inside the cars.

McKinsey: *Will MRT Jakarta ever be economically self-sustaining?*

Sabandar: We want to become the model for building transport systems as well as operating them—including commercializing them. If you only rely on ticket revenues, it's difficult to turn a profit because the tickets will always be subsidized. It's not healthy for a company to continue to be subsidized.

That's where nonfare revenue—the money we can make from advertising, retail, telecommunication, and naming rights—comes in. Initially, our target might be for 30 percent of our total revenue to be nonfare. But it's already gone beyond our expectation, and nonfare revenue is on track to beat our farebox revenue this year. I'm confident that, by the second or third year of operation, we'll cover our operations budget with the combination of farebox and nonfare revenue.

McKinsey: *What kind of technology solutions have you deployed for the MRT?*

Sabandar: In construction, we used a tunneling technology that's more commonly used in mining. Nobody had used it for transportation in Indonesia before. For the surface, we installed platform screen doors in the stations that block

heat from the rail, so it's more energy efficient. These doors improve safety as well.

We also installed an automated train system, which helps the reliability of the system as well as safety, as the train will always be controlled by an operation command center. If a train ever goes too fast, for example, an automatic train protection mechanism will slow it down.

McKinsey: *How do you see the mobility landscape in Jakarta evolving?*

Sabandar: The first line—these 16 kilometers—is the beginning of realizing our vision for the future of mobility in Jakarta. Our goal is to build 230 kilometers by 2030. That includes the second-phase north line, the third-phase east-west line, and then the inner- and outer-loop lines. We're also working to expand station access. Some of the elevated stations are in buildings that the public can't easily access, so we're discussing a skybridge with the developer. And in future phases we'll build these interconnections from day one.

To encourage increased ridership across all modes of public transit, we also want to integrate the various systems. We've already seen ridership on TransJakarta, our bus rapid transit system, increase from 700,000 to 800,000 people per day. Next, we want to integrate the ticketing systems and issue multimodal tickets. We're currently working with Kereta Api Indonesia, which serves more than one million passengers per day, to issue a ticket that works on both Kereta Commuter Indonesia and MRT Jakarta. That will form the backbone of the ticketing system, which can eventually serve the bus rapid transit, the light-rail train (under construction), and other transport modes.

The second-most important objective is to distribute Jakarta's urban growth by building reliable public transit. MRT will help create new urban centers, distributing not just the community but also the traffic patterns, and that

will create more opportunity for development in Jakarta's suburbs. People can live near a station and work in the city center without having to commute by road.

Today, only 20 percent of the total travel in Jakarta is on public transport. Our vision is to see that share increase to 80 percent.

McKinsey: *What is your vision for MRT Jakarta as an organization?*

Sabandar: The company has a lot of potential to support the development of public transport systems in other cities and countries. We want to be like the mass rapid transit organizations in Hong Kong or Japan, providing consultancy for development of MRT systems. I've already been approached by leaders of other Indonesian cities, and we are actively working with them and drawing on what we've learned from our journey in Jakarta. Together we will continue to develop world-class infrastructure throughout the region. ■

¹ Viriya Singgih and Arys Aditya, "The \$43 Billion Race to Fix Jakarta's Choking Traffic," *Bloomberg*, February 26, 2019, bloomberg.com.

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Preparing our cities for shared autonomous-vehicles

What infrastructure improvements will promote the growth of autonomous vehicles while simultaneously encouraging shared ridership?



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Imagine a future in which fleets of autonomous buses and shuttles effortlessly navigate through city streets to their designated stops. Ridesharing services dispatch shared autonomous vehicles (AVs) to pick up multiple passengers traveling along similar routes. Car ownership and traffic congestion drop because shared-mobility AVs fulfill most transportation needs.

Now imagine an alternative future in which everyone who once owned a traditional car instead has an AV. Many people without licenses also purchase AVs for their personal use, even though they haven't had a car for years or never owned one. Passenger-miles traveled increase by 25 percent and city streets become even more gridlocked.¹

Which scenario will emerge around the world? The answer will depend, in part, on whether public and private stakeholders invest in the infrastructure required to enable shared autonomous mobility (SAM). Here's a look at the benefits that stakeholders can obtain by pursuing an infrastructure strategy that encourages SAM, as well as some steps that can help them move in the right direction.

Autonomous-vehicle infrastructure at a crossroads

If stakeholders build infrastructure to support SAM, multipassenger robo-taxis could account for 500 billion miles traveled on US roads—about 9 percent of the total—by 2030. By 2040, they could account for 50 percent of all miles traveled. In addition to less traffic congestion, vehicle emissions could plunge. With more AVs in use that make fewer errors than human drivers, transportation fatalities could decline. Real estate previously dedicated to parking could be repurposed into commercial or residential properties. These improvements, in combination, could produce economic benefits totaling \$850 billion annually.

Basic upgrades: Keeping infrastructure assets in good repair

Some of the upgrades essential for SAM are simply intended to make the roads friendly to AVs. Currently, only 41 percent of US roads meet the requirements for a “good ride,” as scored according to the International Roughness Index. Potholes, poor striping, and other maintenance issues not only create safety problems but also present challenges to AVs. For instance, the physical structure of intersections will change if roads or markers deteriorate, making it difficult for mapping software to guide AVs accurately. If governments consider adopting faster, more efficient approaches to improving basic infrastructure, they could reduce such problems and enable greater AV use. Governments could also eliminate some issues by contemplating partnerships with various stakeholders, such as utility companies, transportation departments, and cable companies, to ensure coordinated and cost-effective street repairs. With fewer detours and road closures, AV navigation will be easier.

Shared mobility: Shaping the future of transit

Other infrastructure upgrades are specifically designed to encourage SAM. These alternations may not be an immediate concern for public officials who are busy juggling priorities and dealing with tight budgets. But acting now on a forecasted need is less costly than acting later on an existing or emerging need. SAM investments could also produce some immediate improvements in congestion and transportation, even though traditional vehicles far outnumber AVs.

Some of the most important structures and accommodations needed for SAM include the following:

- **Support facilities.** Autonomous fleets will need large support facilities to service and charge AVs. If cities allow private companies

to operate vehicle fleets, officials might only need to regulate support facilities; their private partners would bear all infrastructure expenses. But if officials want to create public fleets, they should consider planning for the development of support facilities, much as they do when creating or enhancing today's bus systems. In some cases, they could repurpose existing facilities that are no longer essential, such as parking garages.

- **Staging areas.** To avoid congestion, AV fleets and shared-ride services need locations where they can idle when picking up or discharging passengers. One solution might involve converting existing parking spots into staging areas accessible to multiple fleet operators.
- **Curb modifications.** In most cities, the curb predominantly serves as a space for parking. Transportation leaders could consider pricing this resource more dynamically, taking market demand into account, to free up spaces. They could also designate it for specific purposes at different times (designated with signs or beacons that send signals to AVs). During rush hour, the curb might be a pickup site for AV shuttles that are part of the public transportation system. Later, it could provide parking for food trucks during lunch and a site for freight delivery at night. Transforming the curb may encourage SAM because travelers could share costs related to drop-off, especially during times when the price increases. Dynamically pricing curb space could also reduce congestion and cut down on vehicles circling—current problems that will extend into the AV world of the future.
- **Mobility hubs.** For SAM to flourish, travelers must be able to [transfer seamlessly](#) between different modes. A commuter might take a robo-taxi from home to the nearest train station then grab an electric scooter to get the final mile from the train stop to the office. If this process is too difficult, passengers might opt to take

a private AV from point to point—a trend that would increase delays and unreliability. To avoid this situation, officials could consider investing in more mobility hubs where travelers going in the same direction can access shared transportation, including AVs. These facilities could include micromobility-pickup locations (places where people could get scooters or bikes) next to subway stops or large transit facilities that also contain dining and shopping options at critical nodes.

Funding autonomous-vehicle-infrastructure upgrades: Possible approaches

Federal, state, and local governments are already struggling with budget deficits, and transportation is underresourced. According to the American Society of Civil Engineers, the United States has a \$836 billion backlog of highway- and bridge-capital needs.² Adding to the problem, the growth of AVs and EVs could exacerbate the current funding gap by 22 percent—about \$80 billion—by 2040. (Given that most AVs will be [electric](#), fuel-tax revenues may fall by more than half). And without the need to license and register drivers or personal cars, various fees could also fall substantially. These shifts will likely present a daunting financial challenge for the public sector.

Public officials could mitigate the funding gap by finding new revenue streams. When considering their options, it would be helpful if they investigate whether new revenue streams would incentivize or discourage more cost-efficient SAM. In many cases, these streams may come from public-private partnerships (PPPs), which are becoming more common with large transportation projects.

PPPs provide means for encouraging the diverse mix of capital investments that may be needed to support the growth of AVs and SAM. (No single public or private organization has the resources needed to make all required infrastructure upgrades.) With all PPPs, careful consideration

must be given to ownership issues, contract terms, and the potential value of the future revenue streams. Prime [mobility-related PPPs](#) that encourage SAM might focus on the following activities:

- developing the infrastructure necessary to price the curb dynamically and collect revenues (for instance, by installing smart meters that display current prices, accept payments, and notify servers if they are occupied)
- bundling a variety of small capital improvements across a broad geography to capture economies of scale and attract the most efficient and sophisticated private-sector companies (for instance, by repairing multiple bridges simultaneously)
- setting up and operating mobility services, such as AV fleets, on behalf of a city, following the model that some have implemented for bikeshare programs
- constructing infrastructure to collect user fees on shared-AV-only lanes



The greater use of shared AVs won't just change transportation systems—it could also breathe new life into cities. If transportation officials begin looking into SAM issues now, before AVs become widespread, they can create a future in which traffic flows smoothly and predictably, public transportation operates efficiently, and overall emissions drop. Residents could have more parks, restaurants, and businesses to enjoy in their own neighborhoods, giving them a greater connection to the local community. Risks to bicyclists and pedestrians, which have been growing in recent years, could also fall. The benefits that such changes could bring to society and the environment could be beyond price. ■

¹ Eric Hannon, Colin McKerracher, Itamar Orlandi, and Surya Ramkumar, “An integrated perspective on the future of mobility,” October 2016, McKinsey.com.

² “Roads,” *2017 infrastructure report card*, American Society of Civil Engineers, 2017, infrastructurereportcard.org.

A longer version of this article appears on McKinsey.com: [A new look at autonomous-vehicle infrastructure.](#)

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New mobility maps out a 21st-century course for transport infrastructure development

Five actions can help players across the private and public sectors move toward new mobility. Collaboration is key.



David McAlister

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WSP

Mobility as we know it is in transition. Just as the invention of the internal combustion engine (ICE) led to widespread production and use of the automobile throughout the 20th century, today, emerging and new technologies are paving the way for a dynamic era as new mobility becomes the bedrock of future transport systems.

Throughout the world, the bundle of transport and technology changes known as new mobility will transform and improve the ways we move about, live, and interact with each other. New mobility will also open doors to address an array of critical 21st-century issues, including the need to reduce urban congestion and greenhouse gas emissions. As environmental, economic, and social sustainability concerns refocus metropolitan planning and design efforts, new mobility will inform and shape a well-considered approach to infrastructure development.

In land transport specifically, technological change is already at work in live operations, pilots, and trials. Four elements—automation, connectivity, electrification, and shared use—form the core of new mobility. Business models will continue to influence and bring together developments across these main areas, generating benefits for both the private and public sectors. Five specific actions—mapping your organization’s “now” against the elements of new mobility, understanding your organization’s appetite for change, collaborating consciously, adapting what your organization already has, and finding your springboard for action—make an effective starting point.

Core elements of new mobility

Each new mobility element has a distinct and essential role in producing the greatest long-term benefits for people, places, and communities.

Automation and connectivity will together transform future network efficiency, safety, and access to mobility. Where applied, these elements will allow the creation of data-led, multimodal transport systems. Governments around the world

are developing regulatory frameworks that set the conditions for automated vehicle testing and deployment. For example, Dubai is focused on creating an integrated system of people, vehicles, and physical and digital infrastructure, with the goal of making 25 percent of all trips in the city smart and driverless by 2030.¹ The City of San Diego is upgrading streetlights to create a connected digital network that can optimize parking and traffic, improve public safety, and track air quality. The City plans to implement 3,200 smart sensors, which will be the world’s largest city-based deployment of an Internet of Things platform.² San Diego is also developing a smart-city dashboard to manage parking and curbside use, and to see real-time usage throughout the day.

The immediate benefits of electrification are well-recognized across government, in the private sector, and by consumers. Reduced costs for users and healthier air quality due to lower local emissions will be major advantages. Electric vehicles (EVs) also offer the potential for higher reliability relative to ICE models. A global movement toward zero-emission transportation solutions, in great part driven by battery-electric propulsion, indicates worldwide progress and potential. California is leading the way in the United States, calling for transit to be zero emission by 2040 and for a ban on registration of new ICE vehicles starting in 2040 through its Innovative Clean Transit Rule and the Clean Cars Act. France and the United Kingdom have an official target of no new ICE vehicles sold after 2040. Norway plans to sell only EVs by 2025. At least 16 countries have taken action to phase out ICE vehicles and increase the number of EVs.³

Finally, shared use of motor vehicles holds transformational power in terms of future place-making across our cities, towns, and rural centers. Ridesharing can discourage car ownership, resulting in far fewer vehicles driven and parked. But a substantial move away from private vehicle ownership will depend on the availability of a high-quality, flexible, and affordable mobility service

that works better than today's car ownership and lease models.

And increasing EV adoption across ridesharing fleets deepens new mobility's impact. For example, MOIA, a subsidiary of the Volkswagen Group, recently launched the operation of 100 EVs in Hamburg as part of the company's ridesharing service, with the aim of the shared-mobility fleet growing to cover the entire city in the near future.⁴ New residential communities that support a car-free lifestyle are also becoming a reality; the Parkmerced development in San Francisco provides users with transportation credits in exchange for car-free living.⁵

Business models and revenue generation will bring about the transition from today's mix of pilots and trials to proven and established new mobility options for the long run. One example: mobility as a service (MaaS) is offered with subscription-based mobility packages on the Whim application in Antwerp, Belgium; Birmingham, England; and Helsinki, Finland.

Five steps toward new mobility

Initiating or continuing a new mobility effort requires a clear vision and an understanding of the possibilities in evolving new mobility landscapes. These five steps can help direct and guide your organization's plan of action.

1. Map your organization's "now" against the elements of new mobility

Some organizations may initially have an interest in only one or two of the four elements of new mobility—particularly those advancements that bring a specific technological solution to market. In the automotive industry, for example, some firms are focused on connectivity and electrification, while others, such as Volkswagen with MOIA, are extending their new mobility brand through shared use. Planning and transport authorities are more likely to favor a balanced approach across all four new mobility areas, with an eye on wider social benefits.

Being eager to engage with new mobility does not mean that everything must be decided and mapped out right now. There will be many unknowns, and much change ahead, so the first step is to identify which decisions are needed immediately and which ones can wait. For example, retail landowners should start assessing the resilience of their shopping malls, both in terms of having transport facilities that can accommodate shared mobility and being able to engage with customers through new mobility business models. Doing so will enable commercial property owners to maximize the accessibility and revenue-generating potential of their assets.

2. Understand your organization's appetite for change

Appetites for new mobility and the power to accelerate or hold back change vary widely in both the public and private sectors at national and local levels, ranging from "we'll wait and see" to "we want to be at the forefront." Organizations with a longer-term adaptive plan—one that allows integration of new mobility options and aligns them with core strategy and operations—will be positioned to move ahead. Pilot programs—a manageable way to get your organization's feet wet—and conducting due diligence in local markets are key to test concept viability before widespread implementation. Large business parks and university campuses are trialing automated shuttles that move staff, students, and goods, testing the interactions and use cases in a relatively controlled, low-risk environment.

3. Collaborate consciously

Sustained results require multifaceted collaboration to maximize returns and accelerate change. Diverse professionals—technologists, funders, visionaries, and others—craft and shape the landscape, then reshape it as necessary. By putting a focus on the potential positive long-term outcomes—increased land value, cleaner air, more efficient networks, and safer roads—new mobility can draw together city and area leaders, transport

planners, urban designers, transport-network owners, and mobility and technology providers to engage in meaningful collaboration toward diverse community goals. Working together, public and private sector stakeholders can then understand how to approach their new mobility options and take practical, near-term steps toward actualizing transport systems underpinned by new mobility.

At hotspots where pilot testing can be scaled into commercially viable services, opportunity may exist to align interests. Say a lead partner, perhaps a local government, has set a vision for shared, electric, and automated mobility. Stakeholders across multiple areas—automotive, academia, utilities, local businesses, and existing operators—looking to make that vision a reality can engage by providing in-kind contributions such as sharing of data. This information can range from automotive technology timelines and infrastructure requirements to operators’ passenger travel demand data to academic insight into what service model may work best.

4. Adapt what your organization already has

Ask whether some of what is already planned or available can be adapted to enable new mobility. Rethink and adapt existing investment plans to work with what you see on the horizon. Movement toward electric and autonomous vehicles, for example, will influence land use and have an impact on traditional parking requirements. Land and facilities currently used for parking can be freed up for recharging of new-mobility vehicles. Adding a couple of charging stations to an existing parking lot may be a good place to start now.

5. Find your springboard for action

Identify a specific focal point that can be delivered in the short term to make a statement about the tone, style, and speed of your organization’s move toward new mobility. This choice may align with a prior involvement in existing pilots and trials or an area where your organization is already in a market leadership position; or it may be an area where your organization is trailing but where you can see

enormous short-run potential for visible change and benefit. Large sporting or cultural events often provide a platform for testing new initiatives with a receptive audience. At the Tokyo 2020 Olympics, plans call for automated and electric vehicles to help move athletes, officials, and media between venues and the city center.⁶



We are challenged to design and create new mobility futures that are equitable and sustainable to support the needs and wants of individual communities. While each element of new mobility will increasingly reshape our transport systems in the coming years, there is not one easily defined new mobility “bundle” that will work everywhere. As government regulators and private industry collaboratively prepare for the integration of new mobility, they will enable communities to deliver the many benefits of new mobility throughout the 21st century and well beyond. ■

¹ “Transforming Dubai to autonomous mode by 2030,” Dubai Future Foundation, Government of Dubai, accessed June 10, 2019, dubaifuture.gov.ae.

² “Smart City—San Diego,” Smart Cities Library, accessed June 12, 2019, smartcitieslibrary.com.

³ Isabella Burch and Jock Gilchrist, Survey of Global Activity to Phase Out Internal Combustion Engine Vehicles, Center for Climate Protection, September 2018, climateprotection.org.

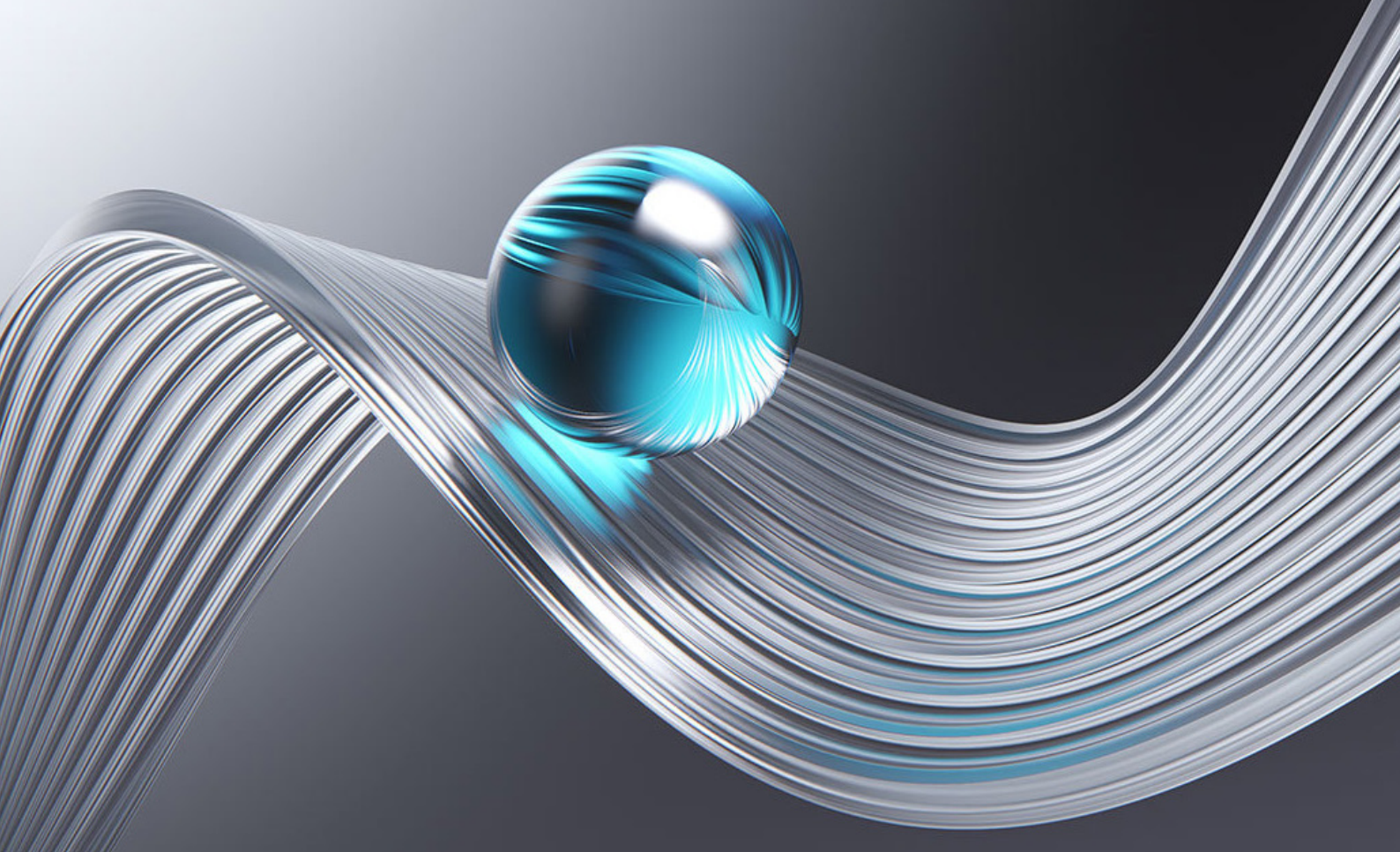
⁴ “MOIA: The e-shuttle against the traffic gridlock,” Volkswagen, accessed June 12, 2019, volkswagenag.com.

⁵ “Car-free living,” Parkmerced, accessed June 12, 2019, parkmerced.com.

⁶ Steve McCaskill, “How autonomous and electric vehicles will keep the Tokyo 2020 Olympics moving,” *Forbes*, July 25, 2018, forbes.com.

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Setting course for a future of seamless mobility

Urban traffic is getting worse. Here's how public- and private-sector leaders can forge a strategy toward seamless mobility.



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The age of modern transit began in 1863, when the first underground railway began rolling in central London. The line was short and smoky, and nothing like it had ever been seen before. But it worked, and cities around the world began to follow London's lead. Over time, city authorities came to see providing transportation as one of their core responsibilities, and governments often owned and ran transit systems themselves.

The future, however, could be very different. Under what we call "seamless mobility," travelers mix and match different kinds of transit, ranging from trains and bikes to robo-taxis and autonomous shuttles. Rail would remain the backbone of the urban transit system, delivering about 40 percent of urban passenger-kilometers. But there will be more people in shared modes of transportation; over time, all of these will be electrified, and many will be autonomous.

We have identified five indicators to evaluate mobility systems: availability, affordability,

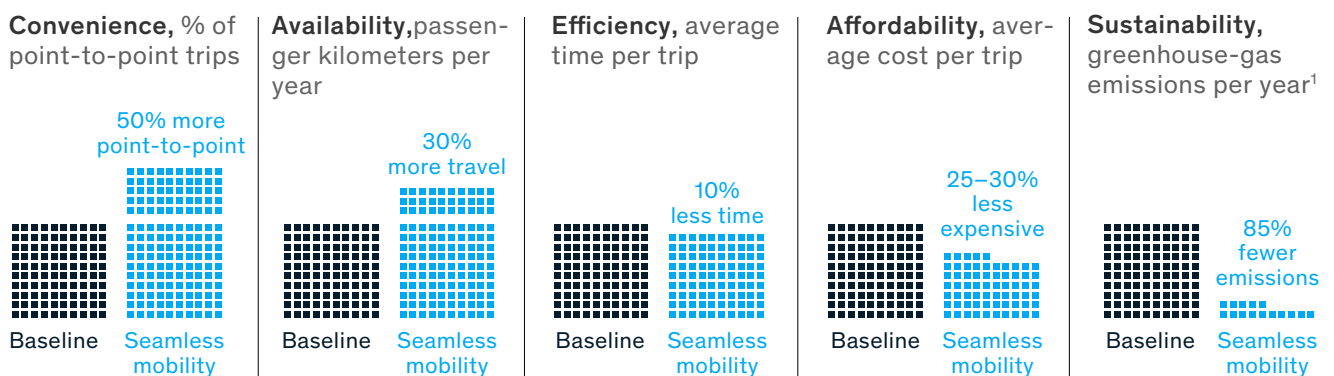
efficiency, convenience, and sustainability. By integrating four trends—autonomy, connectivity, sharing, and electrification—seamless mobility improves all of them. Specifically, we believe it could accommodate up to 30 percent more passenger-kilometers (availability) while still reducing average time per trip by 10 percent (efficiency). In addition, it could cost 25 to 35 percent less per trip (affordability), increase the number of point-to-point trips by 50 percent (convenience), and, if AVs are electric, reduce greenhouse gas (GHG) emissions by up to 85 percent (sustainability).

To get there, it is critical to maintain a high-quality physical infrastructure those Victorian engineers would have been familiar with. But seamless mobility will also require new kinds of physical assets, such as storage and maintenance facilities for shared autonomous fleets, fast-charging infrastructure for electric vehicles (EVs), and dedicated lanes for autonomous vehicles (AVs) equipped with vehicle-to-infrastructure

Exhibit 1

Seamless mobility has the potential to improve all system indicators.

System indicators, change over baseline



¹Assuming that all electric vehicles and autonomous vehicles are powered by no-emissions sources.

communications and IT systems. All of this comprises a significant new area of opportunity for infrastructure companies to design, build, and operate, and for new forms of public-private partnerships.

Under seamless mobility, these kinds of hard assets will not only need to be well-built; they will also need to be smart and connected. And that brings us to new kinds of infrastructure, much of it in the form of bytes and clicks, such as traffic-flow management, real-time public-transit information, vehicle routing, maps, and vehicle tracking.

Some of this, of course, is already in common use. For example, the application of smartphones, GPS, and the Internet of Things (IoT) to infrastructure and vehicles has enabled newer forms of travel, such as car sharing and e-hailing. It has also made traditional modes more efficient, by making trains run more smoothly and routing buses more efficiently. In some US cities, portions of the bus fleets travel along flexible networks, based on rider orders placed through an app, rather than fixed schedules. All this is just the start of the journey, though. To consider what kinds of infrastructure may be needed in the future, thinking about it in terms of supply and demand can be useful.

Optimizing supply: Improving capacity utilization

It's time-consuming and expensive to build new bricks-and-mortar infrastructure. More important, in many places it will not be necessary if existing assets are used more productively. Here are some tools that cities can deploy to do the latter.

Paving the way for AVs: Priorities range from ensuring that roads have clear signage and are in good repair to devising consistent data standards and communication protocols. The latter can actually boost road capacity because allowing autonomous vehicles to communicate with

each other enables them to drive closer together, meaning more vehicles can travel safely on the same roads.

Automating, and tech-enabling, trains:

Autonomous operations and advanced signaling reduce the space between train coaches, making it possible to achieve higher speeds and carry more people. Dozens of autonomous trains already exist, for both metro lines and for site-specific systems such as airports. When Paris automated its oldest metro line, the average speed rose 20 percent. Condition-based and predictive maintenance, which involves collecting performance data and using statistics to identify and fix problems before they cause breakdowns, can keep trains rolling more frequently and reduce maintenance costs by up to 15 percent.¹

Deploying intelligent traffic systems: These systems minimize wait times and maximize movement through, for example, lights that sense traffic and communicate with each other, as well as dynamic lane allocation, which shifts lanes to the direction with more traffic. Such systems have reduced commuting time in Buenos Aires by as much as 20 percent, in San Jose and Houston by 15 percent, and in Mumbai by 12 percent.

Optimizing demand: from private to shared modes of travel

To progress toward seamless mobility, it's important to encourage people to shift to shared transportation and to move some traffic to off-peak hours. That is what we mean by optimizing demand. If people move away from driving themselves and onto rail, bus, or autonomous shuttles, existing infrastructure can carry more passengers without increasing congestion, and maybe reducing it. That, however, will require new kinds of infrastructure. Examples of demand optimization infrastructure includes:

Creating dedicated lanes for shared vehicles:

Shared mobility solutions, such as car-sharing, e-hailing, and bike-sharing, are all growing, and

the potential is enormous. The emergence of shared, autonomous EVs that are less expensive than owning a private car could transform urban mobility.² If all the autonomous shuttles and buses that enter circulation travel in their own lanes, they will be a faster, more attractive travel option. Cities such as Bogota and Brussels have already found this to be the case with traditional buses.

Scaling e-scooters and shared bicycles: Bike-sharing has also grown rapidly in the past decade. In the United States, the number of bike-share trips increased from 2.3 million in 2010 to more than 35 million in 2017.³ While these modes are still in their infancy, early anecdotes suggest that when e-scooters and shared bikes are linked to transit lines, this makes rail more attractive.

Changing commercial deliveries: Goods transport accounts for almost 20 percent of urban congestion. The construction and use of urban consolidation centers (UCCs) is one option to thin it. These are locations where deliveries are brought and then sent on to cities. That means fewer truck trips, on more efficient routes. Load pooling is another. Commercial vehicles with spare capacity are matched, via an online platform, with customers who need the space. An algorithm optimizes delivery routes and shippers use their fleet more intensively, reducing related mileage by 25 percent.⁴



The future of mobility comprises a significant new area of opportunity for infrastructure companies. They can only benefit, however, if they work closely with governments—and if all parties keep in mind that to deliver the goal of seamless mobility, the development and use of infrastructure will need to be seamless, too. ■

¹ *The rail sector's changing maintenance game*, February 2018, McKinsey.com; Shafiq Dharani, Tom Isherwood, Diego Mattone, and Paolo Moretti, "Telematics: Poised for strong global growth," April 2018, McKinsey.com.

² Aditya Dhar, Dev Patel, Rahul Raina, and Paolo Sandrone, "What US consumers think of shared mobility," November 2017, McKinsey.com.

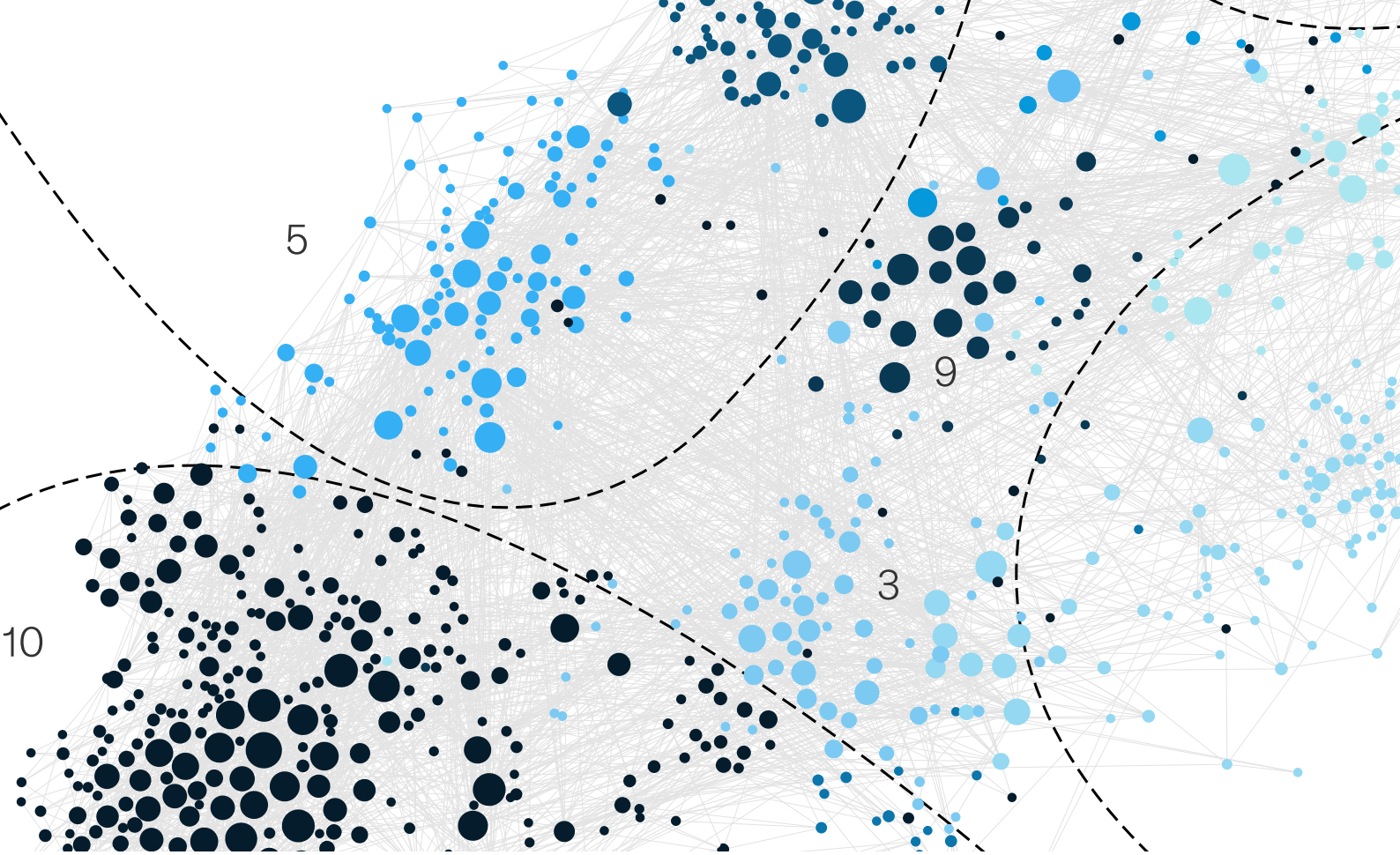
³ "Bike share in the U.S.: 2017," National Association of City Transportation Officials, 2017, nacto.org.

⁴ An integrated perspective on the future of mobility, part 2: Urban commercial transport, McKinsey, September 2017

Read the full version of this research on McKinsey.com: [The road to seamless urban mobility](#)

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Start me up: Where mobility investments are going

McKinsey's latest mobility start-up and investment tally shows the industry invested \$120 billion in the last 24 months.



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The automotive industry is shifting into high gear as a broader definition of mobility takes hold. Driven by the four ACES trends—autonomous driving, connected cars, electrified vehicles, and smart mobility—automotive OEMs, suppliers, and new entrants such as tech players and venture capitalists are attempting to build strongholds in the emerging mobility ecosystem.

We estimate that securing a strong position across all four areas would cost a single player an estimated \$70 billion through 2030. It's doubtful any individual OEM could shoulder this level of

investment alone, which is why partnerships and targeted acquisitions offer an attractive strategy for staying ahead of competitors.

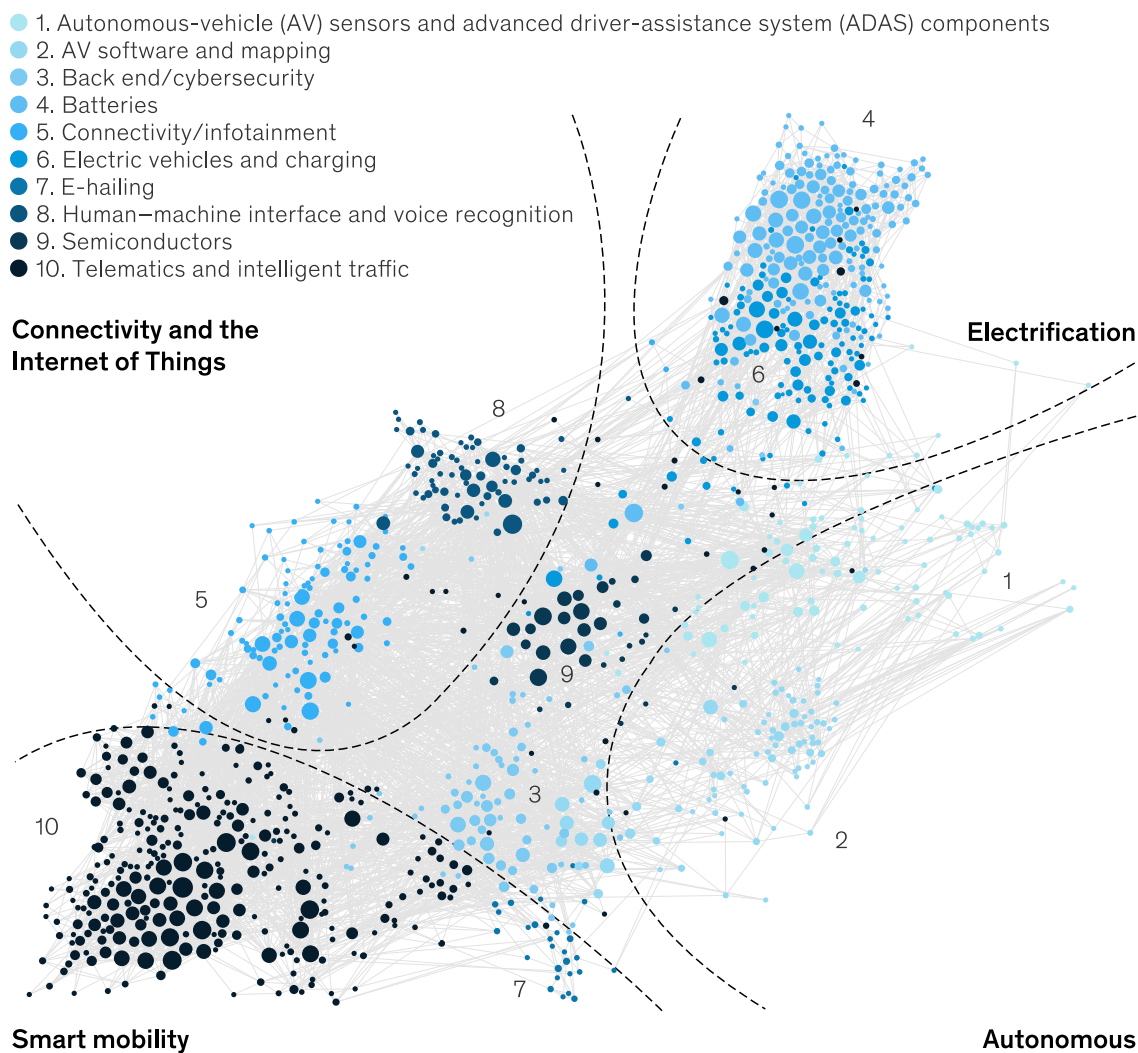
In April 2019, McKinsey undertook a scan of the mobility start-up landscape to identify where innovation and investment are flowing. A few key themes emerged.

Investments continue to grow strongly

Investments in new mobility start-ups have increased significantly (Exhibit 1). Since 2010, investors have poured \$220 billion into more than

Exhibit 1

Analysis on the mobility start-up and investment landscape shows activities across ten clusters.



1,100 companies across ten technology clusters. Investors provided the first \$100 billion of these funds by mid-2016 and the rest thereafter. (Read more on our methodology [here](#).)

One measure of how dramatically investments have grown involves a comparison of the periods 2010–13 and 2014–18, when average investments across all technologies jumped sevenfold (Exhibit 2). Our analysis reveals that more than half of the investment volume comes from large investments with transaction values greater than \$1 billion—these are industry-shaping moves and include

the mergers and acquisitions of established companies.

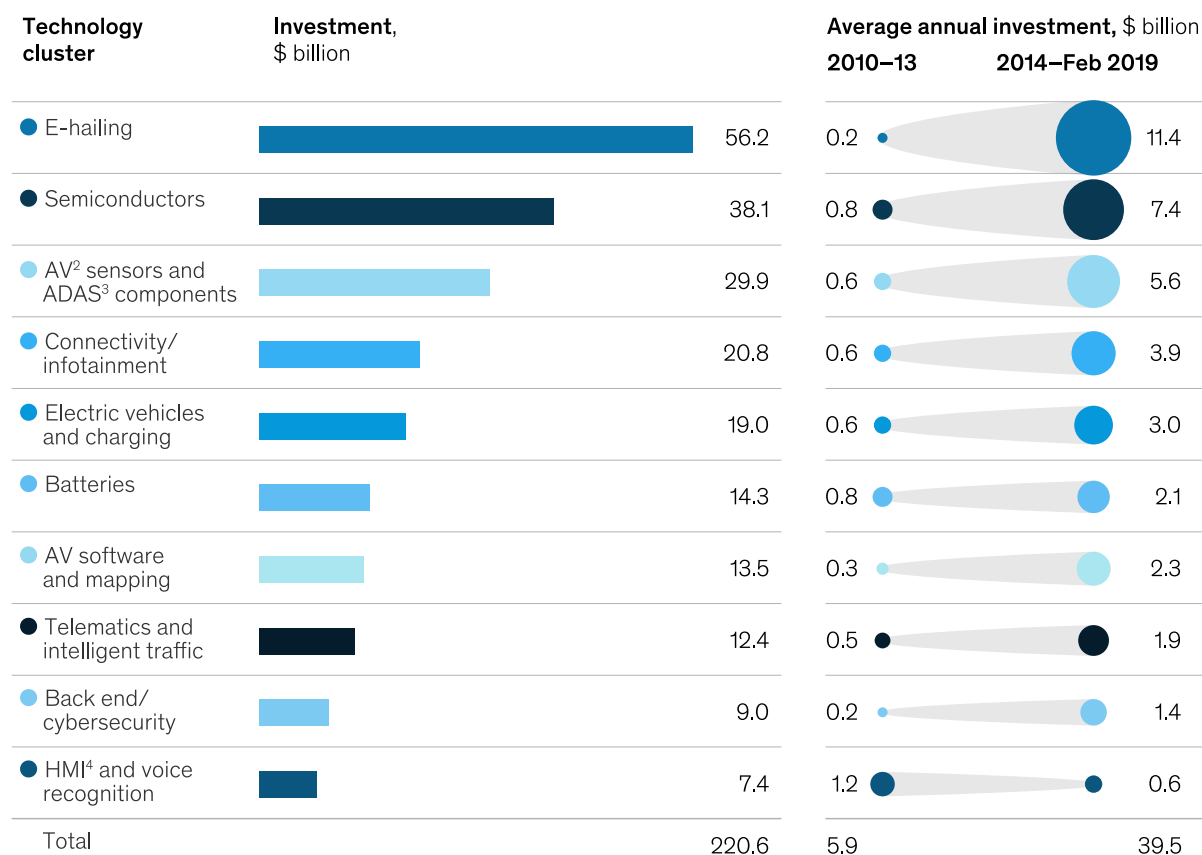
Another clear trend is the tech-company challenge to incumbent automotive players on mobility: these nonautomotive players, together with venture capitalists and private-equity firms, are responsible for over 90 percent of the investments in the mobility space.

Furthermore, we identified another strong acceleration of investments in e-hailing players, mainly driven by large investments in top players.

Exhibit 2

Investment activities accelerated, with a few industry-shaping moves.

Total disclosed investment amount since 2010¹



¹Sample of 1,183 companies. Using selected keywords and sample start-ups, we were able to identify a set of similar companies according to text-similarity algorithms (similarity to companies' business description) used by the Competitive Landscape Analytics team.

²Autonomous vehicle.

³Advanced driver-assistance system.

⁴Human-machine interface.

Source: CapitalIQ; Pitchbook; McKinsey analysis

This indicates that investors expect a high return on investment. These investments, however, need to be seen in conjunction with those in autonomous driving (with several players active in both areas). Autonomous driving can be seen as the endgame of e-hailing, potentially also being the road to (greater) profitability of these solutions.

We also noted several other investment highlights in 2018. For instance, the latest transactions involving Cruise, the autonomous-driving unit of General Motors, reveal a post-money valuation (a company's value after it adds capital contributions and outside financing to its balance sheet) of \$14.6 billion. That alone is responsible for roughly a third of GM's overall valuation on the public market.

What's more, Cruise and Honda are collaborating on a purpose-built autonomous vehicle. Honda will devote \$2 billion to the effort over 12 years and make an additional \$750 million equity investment in Cruise. In May 2018, SoftBank Vision Fund made a \$2.25 billion investment in Cruise, split into \$900 million at closing and \$1.35 billion when GM is ready to deploy its autonomous cars for commercial use.

Furthermore, SoftBank invested an additional \$0.94 billion in Nuro.ai. But autonomous-driving firms were not the only ones to collect significant funds: Grab, a Southeast Asian ride-hailing service, received \$2 billion in new capital from investors including Toyota, which contributed \$1 billion, and SoftBank, which invested \$500 million. Grab's current value is north of \$10 billion.

What's new in the past 12 months—a few highlights

Beyond the overarching development, we have built on our existing analysis to deepen it in selected areas, for instance, considering patent activity, shared micromobility, the rising cost of technology, regional expansion, and other topics.

Patent activity favors incumbents. In addition to investments, which offer one lens on mobility-market dynamics but do not capture internal

company outlays, we also examined technology patents along the ACES clusters. We found that battery and charging technologies account for about half of the relevant patents issued but only 20 percent of company investments. That probably means many large companies do this work in-house via their own research departments. Comparatively, e-hailing services show the lowest number of patents issued, likely because differentiation in this cluster is driven more by network effects and less by technology. Traditional automotive players make less than 10 percent of all investments but issue about 85 percent of relevant patents—an indication they invest more in internal research and development than in inorganic growth.

Shared micromobility debuts. Micromobility companies¹ increased their investments by a factor of more than five from 2014 to 2018. Total investments now significantly exceed \$1 billion, with an average investment of about \$100 million per transaction in 2018. That's comparable to the combined investments in telematics, intelligent traffic systems, and the peer-to-peer space, although the average investment amount is two to three times as high. This investment intensity could support a view that sees it as a supplement to the future e-hailing market (among others), driven by the transition from station-based vehicle sharing to free-floating services.

Technology is becoming more expensive. The median investment amount for relatively smaller deals (less than \$100 million investment volume) has increased two- to threefold since 2013, suggesting that the average cost of technology increased in recent years. This could indicate a maturing of the technology toward industrialization and deployment, as well as an overall increase in the cost of participating in the race for ACES technology.

The regional split is lopsided. Over a third of the overall investment in mobility went to companies in the United States, followed by China (\$51 billion),

the United Kingdom (\$34 billion), and Israel (\$18.5 billion, where \$17.4 billion comes from investments into Mobileye). The next highest European country is France, in tenth position. Even though the European Union (EU), excluding the United Kingdom, receives only 5 percent of global funding, it contains 19 percent of all identified companies. Thus, average investment sums in Europe remain far behind those in the United States and China.

This breakdown is similar when looking at the source of money as opposed to the recipients: the top investors come from the United States, Japan, and China, while the largest investors in the European Union come from Germany, at only \$4 billion.

SoftBank is heavily invested. Japanese tech player SoftBank has invested about \$30 billion in automotive ACES trends to date, with a focus on autonomous driving and e-hailing. With its recent investment in Cruise and Nuro.ai, SoftBank now has a stake of more than \$9 billion in autonomous driving, making it a strong player in the mobility space. An additional \$30 billion has been invested in the semiconductor business, with significant exposure to future-of-mobility topics, in particular the hardware to bring about autonomous driving.

Tech-company valuations outpace incumbents. Comparing today's valuations to those of 2010 shows the total market capitalization of traditional OEMs decreased by more than 10 percent. Meanwhile, tech players in the automotive space—such as Tesla, Uber, and Waymo—increased strongly and are now even higher than the valuations of traditional OEMs. Uber's recent valuation of more than \$70 billion makes it more valuable than traditional premium OEMs such as BMW or Daimler. And although traditional OEMs invest less in inorganic moves, they still hold a strong position in the ACES trends based on their patents and massive R&D expenses.

As the mobility transformation gathers momentum, investors are clearly targeting the four ACES trends, thus providing a concrete measure of the scale and scope of change on the horizon. ■

¹ We define shared micromobility as including electric bikes (e-bikes), scooters (e-scooters), and mopeds (e-mopeds).

Read the full report on this research on McKinsey.com:
[Start me up: Where mobility investments are going](#)

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Four questions on the future of urban mobility

What does the data tell us about the performance of urban transport systems across different geographies?

A dark blue graphic with a white McKinsey & Company logo in the top left. The background features a series of thin, light blue lines that curve and fan out from the left side. In the center, the text "Four questions on the future of urban mobility" is written in white. Below this text is a button that says "Start quiz" in white with a right-pointing arrow. A small white right-pointing arrow is also visible on the right edge of the graphic.

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Four questions on the future
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