McKinsey&Company

An integrated perspective on the future of mobility, part 2: Transforming urban delivery

McKinsey Center for Business and Environment | September 2017

About the McKinsey Center for Business and Environment

The McKinsey Center for Business and Environment works with businesses, governments, and nonprofits to tackle some the world's most pressing and important natural-resource issues in ways that improve both economic growth and resource use.

www.mckinsey.com/client_service/sustainability/mckinsey_center_for_business_and_environment

Contents

Executive summary

Cities are home to more than half the world's population. They dominate culture and politics and are the showplace of some of history's greatest achievements. On a day-to-day level, cities are the heart of the global economy, accounting for more than 80 percent of world GDP.[1] Roads, rails, and other forms of transportation are the arteries that nourish that heart. When these become clogged, businesses, residents, and cities all suffer. And the economic costs are high—as much as 2 to 4 percent of city GDP.[2]

Last year, McKinsey and Bloomberg New Energy Finance published *An integrated perspective on the future of mobility*, which outlined four trends that are rapidly changing passenger transport: electrification, autonomy, connectivity, and sharing. The same four trends will, to a large degree, shape the future of commercial urban transport, which is the focus of this report.

The movement of goods is an essential part of economic life. Commercial vehicles (CVs) account for a significant share of traffic; they take up space and stop and start with infuriating inexactitude. With a billion more people projected to be living in cities by 2030, and with online and other commerce growing, freight volumes are projected to grow 40 percent by 2050. That means many more CVs on the road. Accommodating them will be essential to ensuring the quality of future urban life.

In this report, we identify 20 approaches to reduce congestion related to commercial traffic that are realistic and flexible. The latter is important because cities are different, and solutions that will work in, say, Los Angeles might not be suitable for Beijing or Paris. But some of our solutions—individually and, better yet, combined—will work for all of them. By reducing the number of CVs on the streets, improving efficiency, and shifting the timing of deliveries, congestion and pollution can be greatly reduced. Businesses will lower their delivery costs; consumers will see greater convenience; and cities everywhere will, literally, breathe easier.

With a billion more people projected to be living in cities by 2030, and with online and other commerce growing, freight volumes are projected to grow 40 percent by 2050. That means many more CVs on the road. Accommodating them will be essential to ensuring the quality of future urban life.

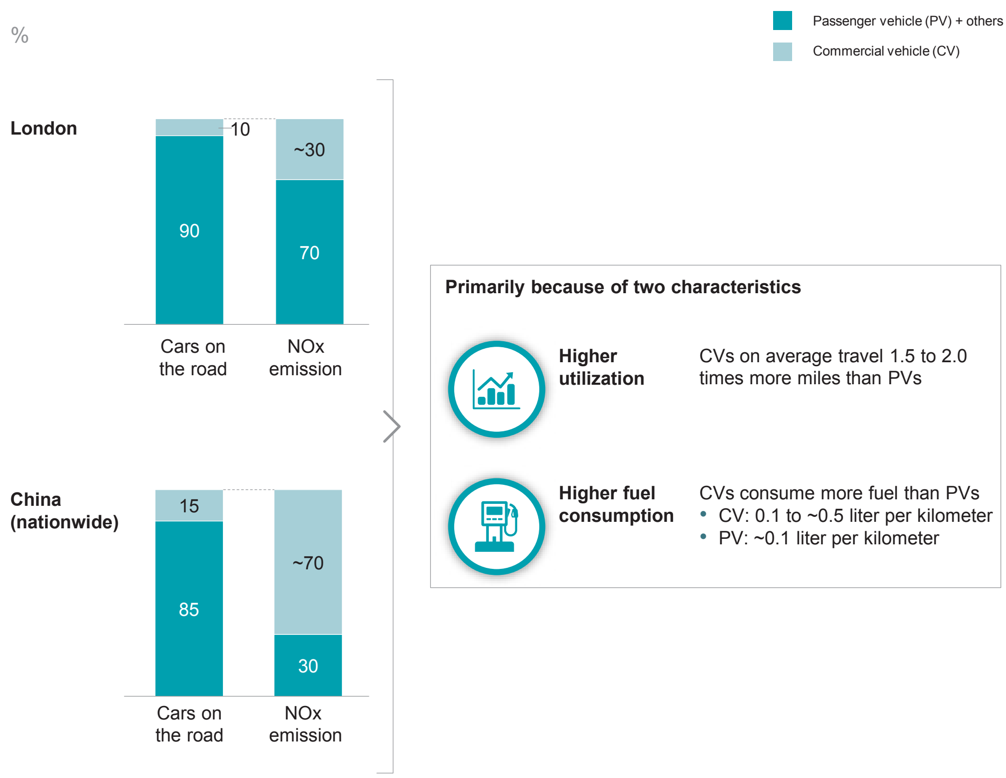
Emerging technologies, such as electric vehicles (EVs), droids, and autonomous ground vehicles (AGVs), will lighten the burden of commercial traffic in congested areas. Even better, there are a number of business models and practices, such as parcel lockers and night deliveries, that have already proved themselves. With a regulatory nudge here and a little creative thinking there, scaling up implementation of these could start tomorrow.

One big problem, six powerful solutions

The commercial vehicles that are on the road today typically generate higher nitrogen oxide (NOx) emissions than passenger cars (Exhibit 1).[3] Also, many of them use diesel engines; compared to gasoline engines, these emit much higher concentrations of particulate matter, a pollutant harmful to health. The consequences can be dire. The World Health Organization estimated that there were three million premature deaths in 2014 due to outdoor air pollution, to which automotive emissions are an important contributor.[4] CVs also contribute to urban traffic woes beyond their numbers. While trucks accounted for 7 percent of urban travel in the United States in 2015, for example, they accounted for 18 percent of congestion.[5] Meanwhile, the demand for deliveries is rising. By 2025, around a quarter of consumers will expect their deliveries the same day, or faster. That will mean even more CVs will be needed (Exhibit 2).

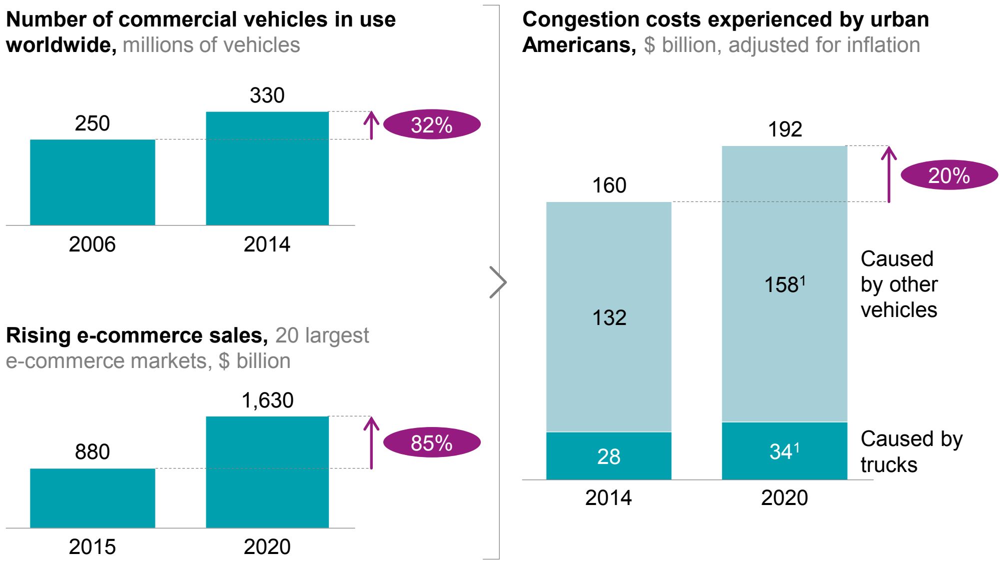
EXHIBIT 1

Commercial vehicles contribute significantly to urban pollution.



Source: China Ministry of Environmental Protection; France Ministry of Environment; KVA; London Atmospheric Emissions Inventory

EXHIBIT 2 The demand for urban commercial transport is rising—and so are the consequences.



1 Assumes same split as 2014 of congestion costs between trucks and other vehicles.

Source: "Number of passenger cars and commercial vehicles in use worldwide from 2006 to 2014," Statista, 2017; *2015 Urban Mobility Scorecard*, Texas A&M Transportation Institute and INRIX; McKinsey analysis

To improve urban commercial transport, we have identified 20 solutions, spread across the delivery value chain from the location of the supplier to the final destination of the receiver. For each one, we evaluated its financial value, social value, and feasibility, given current technology and infrastructure. Of these 20, six approaches look particularly promising.

First, there are urban consolidation centers (UCCs). UCCs are locations, typically on the outskirts of cities, where deliveries are brought, sorted, and then dispatched. Goods from multiple suppliers can be consolidated into fewer shipments, making it possible to optimize loads and truck sizes, thus cutting down on the number of trips and vehicles required. While UCCs have been around for years, success has been spotty. The business case is becoming stronger, however, as new technologies make implementation easier and the expansion of e-commerce makes it more urgent. In a city like New York, we estimate that the use of UCCs could save companies 25 percent on delivery costs per parcel, while reducing miles driven by almost half.

Second, while cities never sleep, when it comes to allowing night deliveries, most of them take a nap, restricting the practice largely because of concerns about noise. It is possible to train people to work more quietly and to require shippers to attach noise-canceling equipment to delivery vehicles, as Barcelona did in a pilot project that has gone national. By using night deliveries, suppliers can drive bigger trucks on less-congested roads; cities would see less peak-hour traffic and lower vehicle emissions.

The solutions make sense in and of themselves. The most powerful effect, however, is when two are more are used together, multiplying their respective strengths. Using a fleet of EVs to supply businesses from UCCs, at night, optimizes vehicle utilization, speeds up delivery, and minimizes noise and pollution. In a city like New York, this triple play could cut costs per parcel by 35 percent, eliminate vehicle emissions if the whole fleet is electric, and require one-third fewer CVs.

The economic costs of congestion are surprisingly high—as much as 2 to 4 percent of city GDP.

What matters, then, is selecting the right options. Different combinations will work for different kinds of cities, different customers (B2B versus B2C), and different time windows (same-day/instant versus multiday delivery). For cities, labor costs and population density will, to a large extent, determine what solutions will work best and how fast they can be adopted. We therefore considered three broad urban archetypes: developed, dense cities such as London or Singapore; developed, suburban cities such as Los Angeles or Sydney; and developing, dense cities such as Beijing or Mexico City.

Developed, dense cities are likely to be at the forefront of change for freight mobility, because governments and companies in these cities can afford to invest in urban planning and cutting-edge technology. Moreover, high wages favor the business case for technology-intensive solutions. Autonomous vehicles, for example, likely will be expensive initially and thus most worthwhile in places with high labor costs.

Developed, suburban cities, where sprawl is the norm, will need to consider a different set of solutions. Because of the greater distances between points of delivery, UCCs and parcel lockers might not be as effective as they are likely to be in denser cities, where it is possible to site them within walking distance of many people. But other approaches, including electrification and night delivery, are still promising. In the more distant future, drones could play a role delivering small and low-weight parcels in sprawling cities, because they can find places to land.

Finally, in developing, dense cities like Beijing, Mexico City, and Mumbai, our analysis showed that deliveries require twice the mileage on average and result in up to two and a half times higher emissions than in developed, dense cities. Due to local road conditions and low labor costs, these cities are likely to be slower to adopt technologies such as AGV lockers. But load pooling and parcel lockers could work well. Combining the right solutions could bring significant benefits—cutting delivery costs 35 percent and vehicle emissions 65 percent.

These 20 approaches, both alone and in combination, can benefit urban economies, the environment, and society. But for five sectors in particular—retail, logistics, the public sector, automotive, and energy—changes in urban commercial transport will challenge their existing revenue and operating models. As the use of online commerce rises, for example, retailers that adopt new delivery solutions could strengthen their competitive advantage, while decarbonizing their supply chain. Automotive companies will face increasing demand for lower-emission (and eventually autonomous) CVs. Innovation and partnerships beyond the automotive sector will be important.

Looking ahead

Improving the way that people and goods move will require new technologies, new business models, and new regulations. But it will also need new mind-sets—among businesses, governments, and consumers—to imagine a future that is different and better than the present.

In last year's report, we explained why all this matters: "Getting mobility right could be a significant competitive advantage for cities. This shift can help clear the air of pollution and reduce traffic deaths. It is an opportunity to improve the quality of life—day in, day out—for billions of people." That argument applies just as strongly, if not more, to commercial transport.

We recognize that making the transition we describe will not be easy. However, we believe that it is beginning to happen—and that the transition could be even faster for CVs. These are used more intensively, which could help to accelerate the introduction of new technologies.

The need for change is urgent. With many more vehicles and people likely to hit the roads in future decades, the time to start preparing is now.

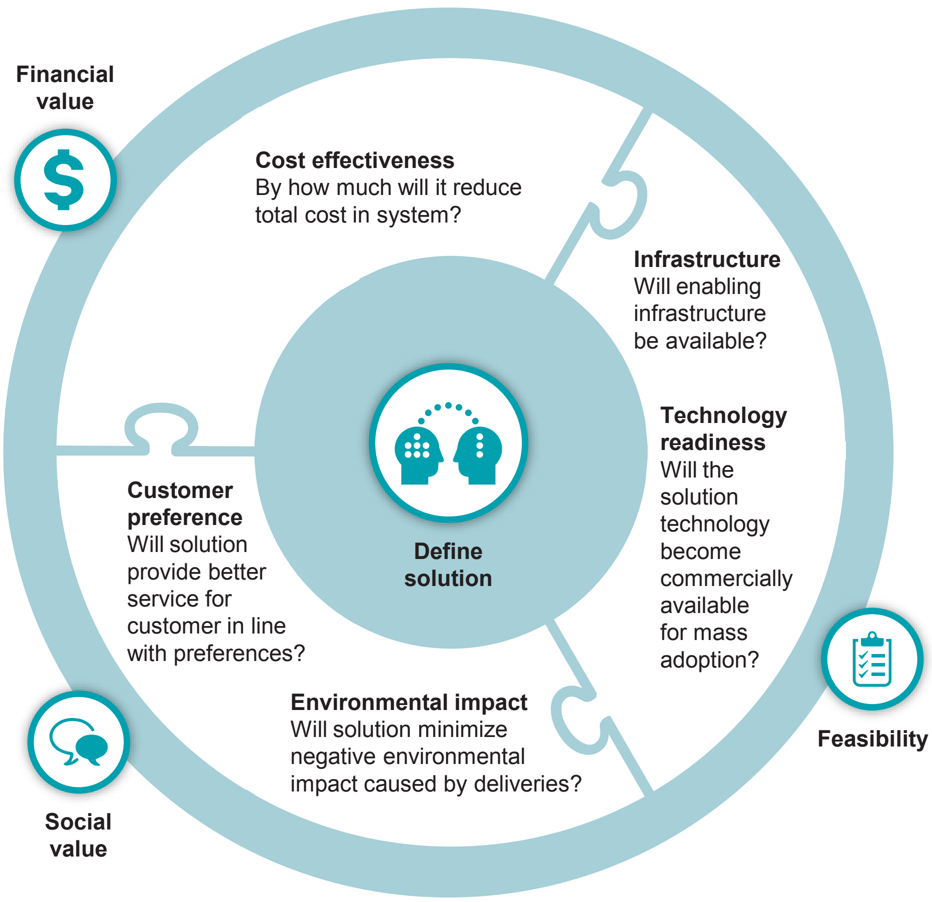
01 Curbing commercial traffic congestion and pollution

Truck drivers' lives are not easy. They drive hundreds of miles in all kinds of conditions, slowing to a crawl as they enter urban areas. There they block city streets, piling up tickets because they cannot find parking spaces, spewing pollution, and attracting blasts from angry drivers. And at the end of the day, they can look forward to doing it all over again. This describes the daily reality in cities all over the world. But it doesn't have to be that way.

There are many ways to mitigate the problems associated with urban commercial transport. In this chapter, we list 20 solutions and assess their potential on the basis of their financial value, social value (for consumers and the environment, in the form of emissions, congestion, and noise), and feasibility (technological, regulatory, and infrastructure) (Exhibit 3).

EXHIBIT 3

We assessed each solution on its financial value, social value, and feasibility.



We grouped the 20 solutions into four categories, according to their place in the value chain: suppliers; warehouse and sorting facilities; transportation; and point of delivery. Transportation accounts for half the total. Other categories show how optimizing commercial transport isn't just a matter of what happens on the roads but also what happens before and after the journey. Some solutions can be realized in the short term; others are years away from real-life deployment.

Six approaches, which we will describe in detail, showed the greatest potential in terms of delivering both significant economic and social benefits:

- urban consolidation centers (UCCs)
- night delivery
- load pooling
- parcel lockers
- electric vehicles (EVs)
- autonomous ground vehicle (AGV) lockers

Solutions that can revolutionize urban mobility

Following are the 20 potential solutions, categorized by place in the value chain.

Suppliers

Order grouping. Group parcels for the same recipient ordered at different times but targeted to arrive around the same time.

Return management. Develop ways to reduce the number of purchase returns, thus reducing trips.

On-demand 3-D printing. Reduce average delivery distance by printing items on demand and near the location of the order.

Warehouse and sorting facilities

Urban consolidation centers (UCCs). UCCs are cross-docking transshipment centers where items are consolidated for delivery into urban areas.

Warehouse logistics. Optimizing, automating, and integrating the flow of materials and information within a fulfilment or distribution center increases the speed of loading and improves truck utilization.

Transportation

Electric vehicles (EVs). EVs are quieter and cleaner than traditional cars, particularly when charged using renewable-energy sources.

Load pooling. The online matching of demand for capacity with available supply maximizes vehicle load utilization; fewer trucks therefore make a greater number of deliveries.

Route optimization. Finding the best way to get from point to point, including constant updates, reduces the mileage and time drivers need to deliver goods.

Combining passenger and parcel delivery. Using passenger vehicles as part of the parcel fleet optimizes road capacity.

Night delivery. Shifting delivery to evening hours, when bigger trucks can be used and traffic is less, can smooth out congestion and reduce the number of trips.

Bike delivery. Bikes are a clean and agile alternative to vans and trucks for low-weight, low-volume deliveries. E-bikes can deliver larger loads over longer distances.

Autonomous light commercial vehicles (LCVs) require minimal to no user interactions for driving; this allows the person on-board to focus on the delivery, minimizing stopping time.

Autonomous ground vehicle (AGV) lockers. These are parcel lockers on wheels that customers open using a personal code.

Drones. Unmanned aerial vehicles could deliver individual packages, using no roads.

Droids. These small four-wheel cars go autonomously from one point to another on city sidewalks, carrying goods for delivery. Unlike drones, which need landing space, droids could be deployed in denser cities.

Point of delivery

Parcel lockers. These are sited in a place where customers can pick up packages at any time with an access code sent to their mobile device.

Individual parcel boxes. These are similar to individual household letter boxes but are large enough to fit parcels and sometimes temperature regulated. The result is fewer failed deliveries.

Click and collect. Buying online and picking up at the store reduces the number of failed deliveries and can help to reduce congestion, as many consumers will avoid peak hours.

Trunk delivery. Use the trunks of parked vehicles, opened with a special key or code, as mobile addresses for package deliveries. Because recipients do not have to be available to accept a parcel, failed deliveries are reduced.

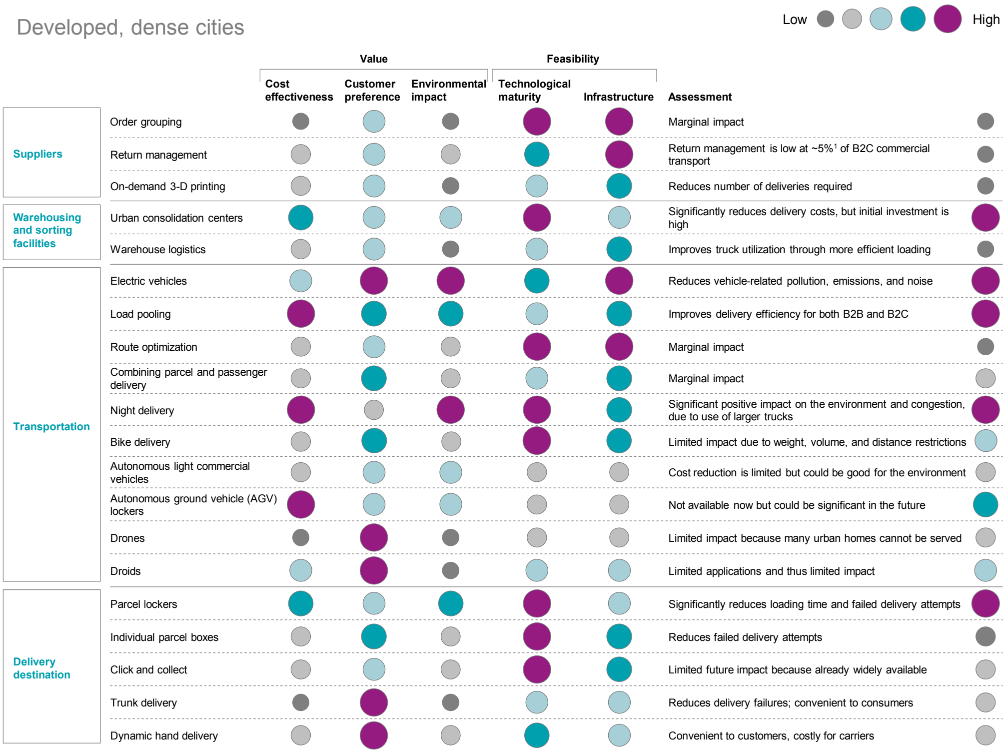
Dynamic hand delivery. Tracking a recipient's location and delivering parcels directly to where the consumer is at that moment minimizes failed delivery attempts.

The value of each of these solutions will vary from city to city, depending on a host of different factors, such as the density of the urban area, local labor costs, and the seriousness of its mobility issues. Some of the solutions, such as AGVs or parcel lockers, depend on a high population density to be economically worthwhile. Those that require either high capital investment or that supplant significant labor costs will be less viable in cities with lower costs of labor. For cities with pressing problems of congestion and pollution, some solutions could provide great relief, even if the near-term economic benefit is less straightforward.

In Exhibit 4, we estimate the impact of the 20 solutions if they were implemented to the fullest extent possible in developed, dense cities—places like London, New York, or Tokyo. (In Chapter 2, we discuss solutions for other archetypes of cities).

EXHIBIT 4

20 potential solutions addressing different parts of the delivery value chain.



1 Return management is mostly applicable to B2C apparel, where it is at ~15–20%; apparel is ~30% of commercial B2C delivery, hence ~5% of BC2 commercial transport.

Six solutions can account for most of the answer

Although all these solutions are promising, six stand out when assessed in relation to cost effectiveness, customer and environmental value, and technical feasibility. We estimate that each of these six solutions, spread across the delivery value chain, can reduce tailpipe emissions by more than 30 percent—and eliminate them altogether through electrification—while also cutting costs per parcel by 25 to 50 percent.

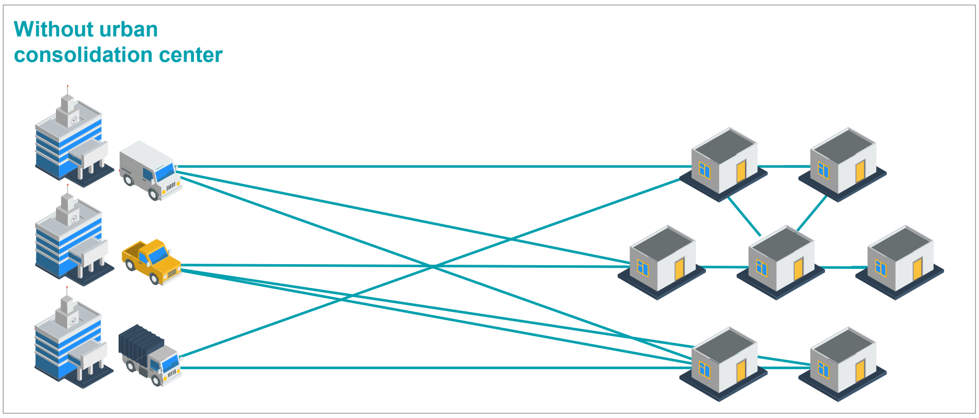
Urban consolidation centers

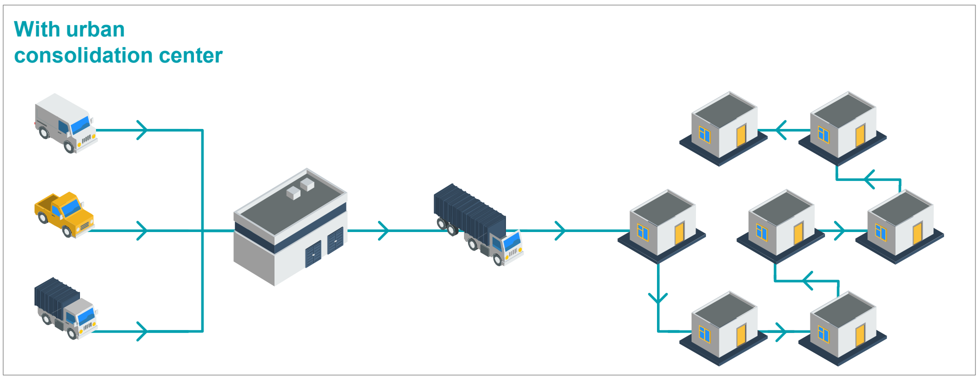
While UCCs have existed for years, success has been spotty.[6] Some have failed due to high costs and less-than-expected demand. Some were located too far from the city center; others were too noisy or did not have effective tracking systems. Those lessons are being incorporated into the next generation of UCCs.

Moreover, a number of trends, such as rising demand for e-commerce, technological advances, and public concerns about traffic and pollution are working in favor of UCCs. São Paulo, for example, is trying to limit the number of trucks entering the city, while London, Singapore, and Stockholm have imposed congestion charges. UCCs work well with these and other efforts, because they encourage the use of more fully loaded trucks that take more efficient routes (Exhibit 5), which means fewer trucks entering congested areas.

EXHIBIT 5

Urban consolidation centers optimize vehicle type and utilization entering an urban area.





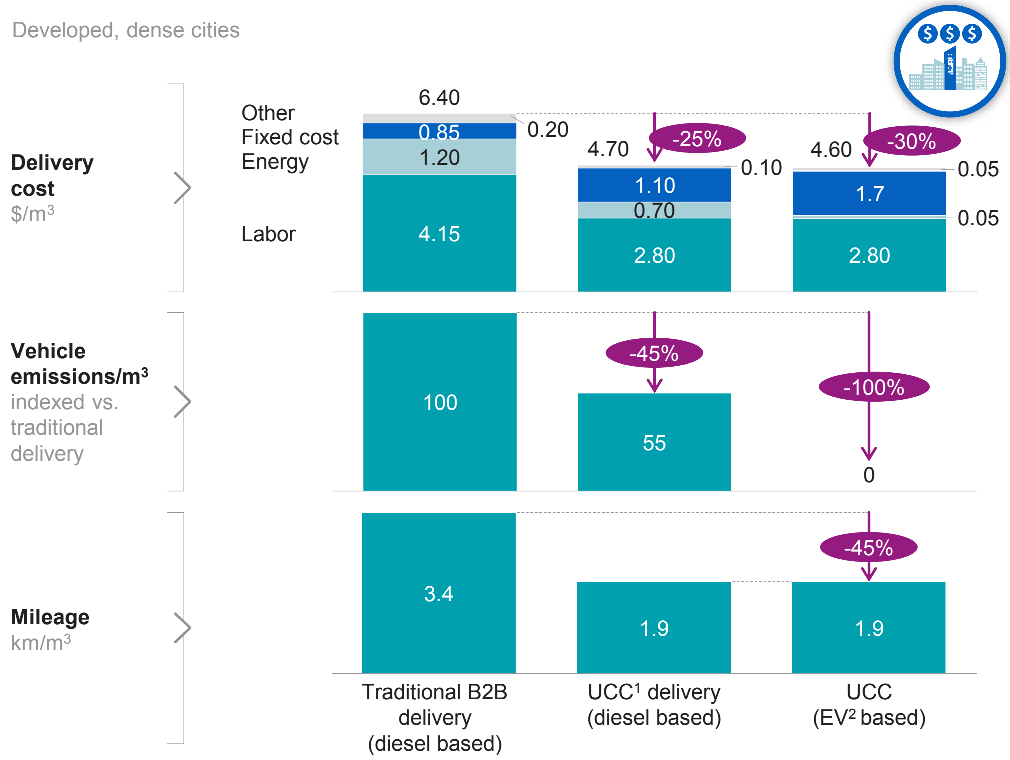
UCCs work by giving companies a location, typically outside but near the city center, to which suppliers and retailers can ship their orders. With the goods gathered in one place, they can be consolidated into fewer deliveries. Most trucks entering a city today are underutilized, with room for more cargo. The use of UCCs allows trucks to be loaded to their maximum capacity, thereby reducing the number of vehicles that enter the city. Experience has shown that UCCs work best in dense cities, no more than 30 kilometers from the center, and close to highways or other forms of transit.

Companies in developed, dense cities that deploy UCCs could save 25 percent on delivery costs per parcel (compared to traditional methods), due to greater capacity utilization, lower labor costs, and fewer miles driven. We estimate that mileage could be reduced by as much as 45 percent to deliver the same volume of goods, thus reducing general wear and tear as well as all types of vehicle emissions (CO_2, NOx, and particulate matter) (Exhibit 6). The benefits in sprawling cities will not be as large due to the greater distances between delivery spots.

Technological barriers to UCCs are minimal, but the capital costs can be high. Still, the investments can be worth it. UCCs that have worked well are often in cities that forcefully promote them, either through direct intervention or indirect standards that help develop the necessary economies of scale (Exhibit 7).

EXHIBIT 6

Urban consolidation centers can reduce delivery costs, emissions, and mileage.



1 Urban consolidation center.
2 Electric vehicle.

EXHIBIT 7

Case studies from the Netherlands demonstrate why UCCs work (and fail).

Case study	Situation	Reasons for success (and failure)
Leiden	• City was congested • Urban consolidation center (UCC) opened in 1997 to help alleviate commercial traffic • After 3 years it closed	• UCC was too far from highway • Delivery area was too small to generate volume needed • Delivery electric vehicles, which went only 1 kilometer/hour, were too slow • Many transport companies did not buy in, suspecting that government was trying to create monopoly
Nijmegen	• City center was congested • This UCC stored deliveries, then delivered on appointment • Retailers paid membership fee in addition to paying for deliveries	• City council supported effort with €100,000 subsidy to allow UCC to build customer base • UCC focused on serving small and independent retailers; these often had poor delivery models • UCC was located near (1.5 kilometers) city center
Utrecht	• City center's narrow roads made commercial deliveries difficult • Quality of life was damaged by noise, pollution, and congestion • Emissions restrictions in city center were becoming stricter	• Private sector paid for development of narrow, zero-emission multitrailer that can navigate city streets while still allowing passing • Local government supported effort by relaxing regulations on delivery times and allowing vehicle to use bus lanes • UCC, which is located near (11 kilometers) city center, loads containers • Service also picks up paper goods and outgoing packages to avoid empty trips

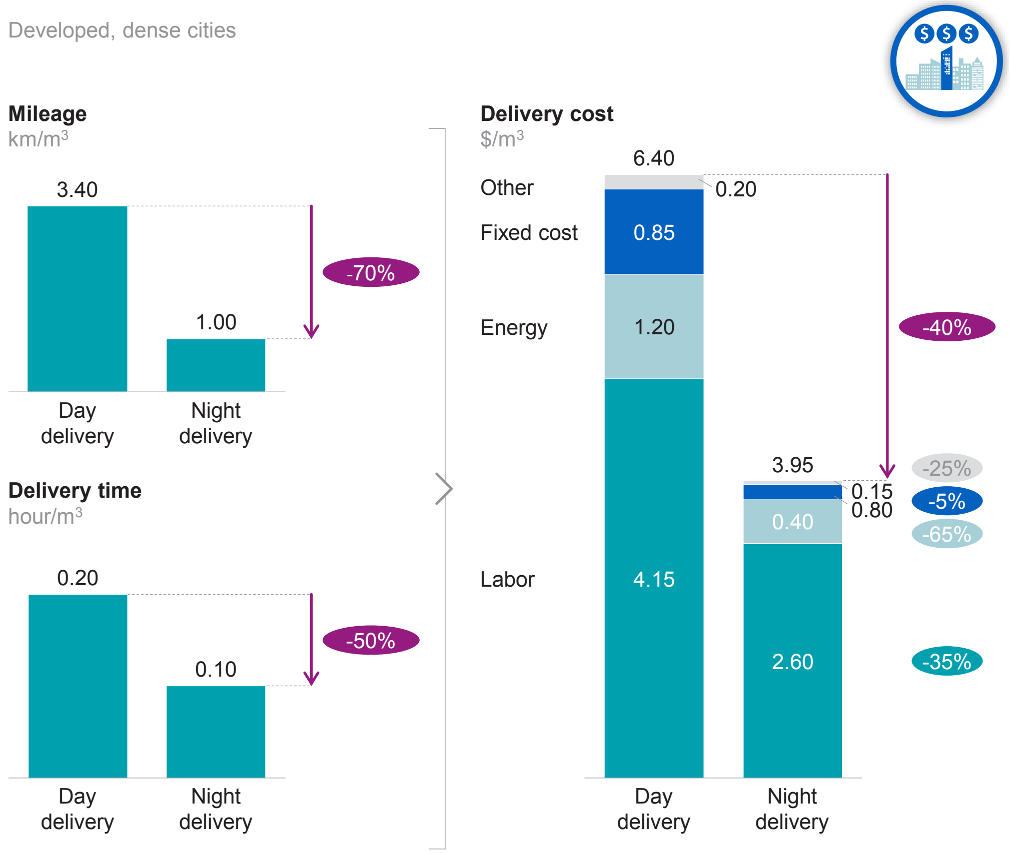
Night delivery

While night delivery is hardly a new or complicated concept, it could nonetheless bring big benefits. The practice is limited at the moment, primarily due to residential noise concerns. Other issues include the higher pay that late-shift workers command and the willingness of consumers, whether individuals or businesses, to receive packages in the off-hours. Nonetheless, for specific applications, night deliveries offer significant improvements; in combination with other solutions, such as night delivery to parcel lockers, many of these obstacles can be overcome.

For example, using electric trucks could help to reduce noise. EVs are markedly quieter than traditional vehicles; that means bigger EV trucks could be used and still meet noise regulations. Using large trucks, which are often banned from the city center during the day, could offset the time-and-a-half premium paid to night-shift workers. Moreover, since these trucks would be traveling when roads are less congested, their average speed could be up to 50 percent faster.

At its full potential in a developed, dense city, night delivery could save up to 40 percent in total delivery costs, while also cutting vehicle emissions, due to fewer miles traveled (Exhibit 8). Not only is night delivery feasible right now, further developments, such as the use of autonomous vehicles, could make it even more economical.

EXHIBIT 8 **Night and day: Shifting delivery times saves miles and money.**



There have already been some promising night-delivery initiatives. In 2003, Barcelona started an experimental program in 20 locations to allow commercial deliveries from 11:00 PM to 6:00 AM. Two larger night trucks could carry as much as seven day trucks. To mitigate noise problems during driving and unloading, delivery vehicles were fitted with noise-canceling devices. The program worked so well that it was subsequently rolled out to more than 140 locations across Spain. One supermarket chain estimated it took less than three years to see a return on its investment, in large part because its trucks could go three times as fast at night as during the day.

Load pooling

This practice matches, via an online platform, commercial vehicles with spare capacity with customers who need delivery space. Load pooling can be used for both B2B and B2C deliveries. Drivers advertise available capacity, delivery routes, and any constraints on goods carried (for example, no hazardous material). Customers post the goods to be shipped and the time and destination of delivery; an algorithm optimizes delivery routes and schedules for both carriers and customers and comes up with dynamic pricing (Exhibit 9).

Shippers benefit from using their fleet more intensively and from higher "drop density" (delivery addresses within a given area); deliveries are picked up directly, no longer going through warehouses, reducing mileage by 30 percent. According to our analysis, at full potential, load pooling in urban areas could reduce delivery costs by up to 25 percent and vehicle emissions by up to 30 percent (Exhibit 10).

EXHIBIT 9 **Load pooling increases efficiency.**

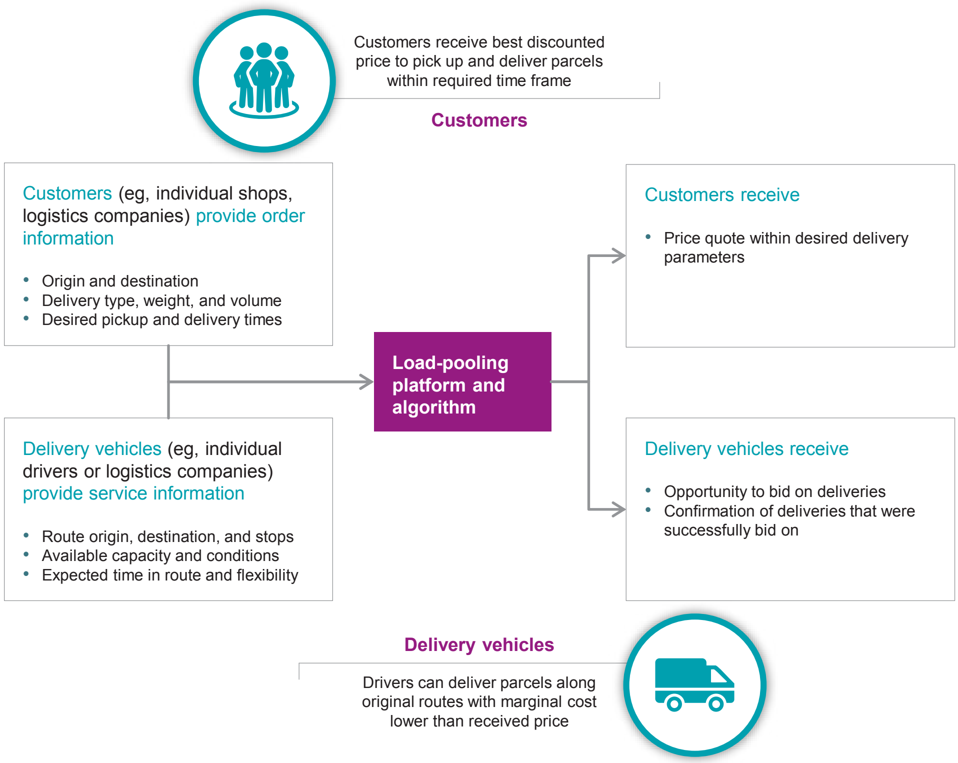
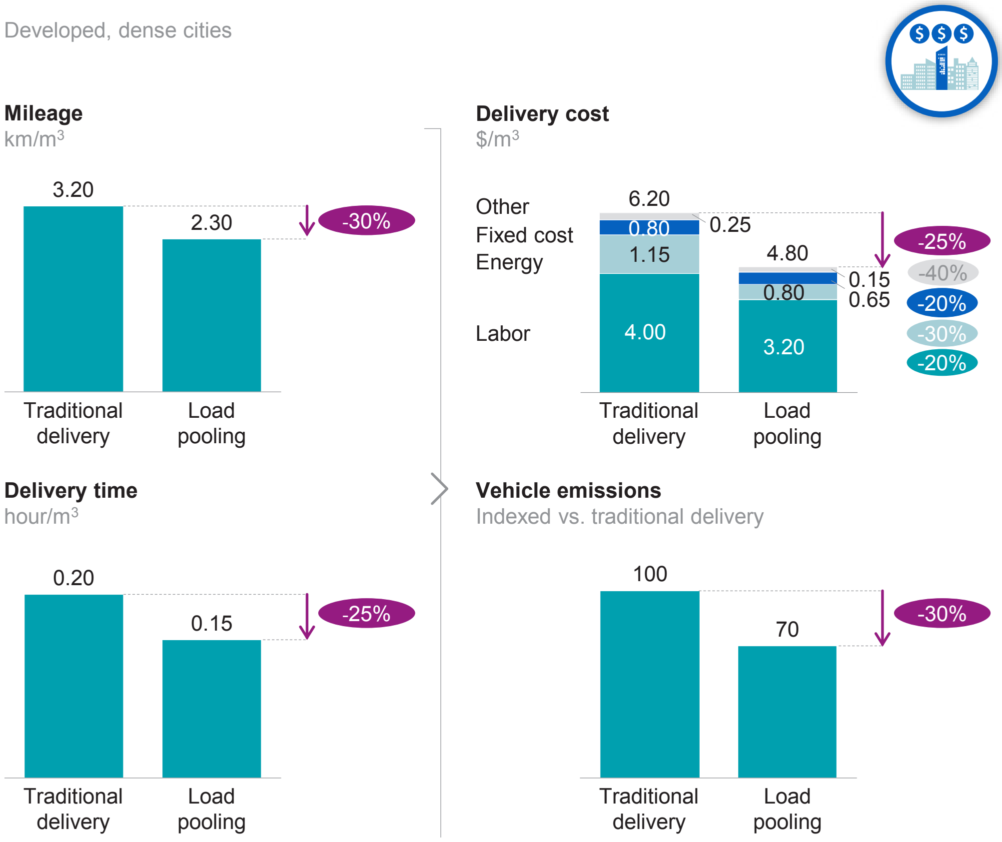


EXHIBIT 10

Load pooling can reduce delivery costs, traffic congestion, and emissions.



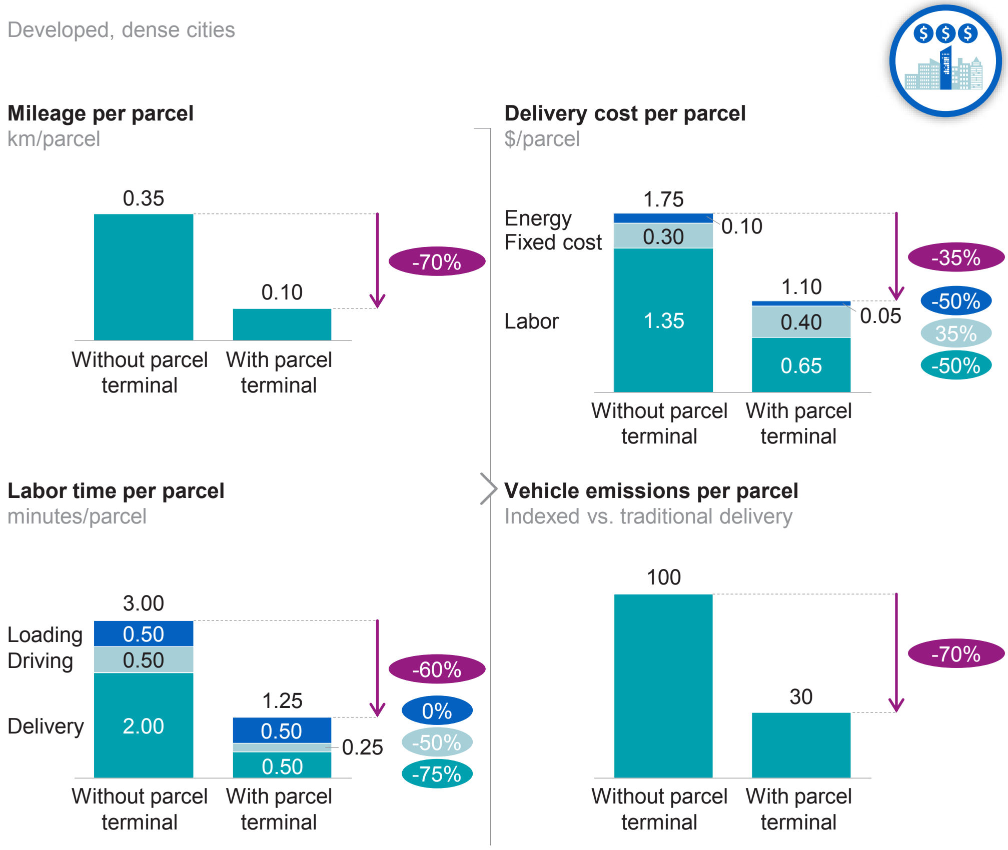
Load pooling, which has few technical barriers and low infrastructure requirements, is already being practiced successfully. Companies such are Uber and Lyft use the principle to move people, and new business models are extending the practice to goods. DHL has a digital freight platform, Saloodo!, operating in 17 countries and using more than 200,000 trucks,[7] while UPS recently bought two brokerage companies—Freightex, a UK company, and Coyote Logistics, which serves more than 14,000 shippers in the United States.[8] Using a similar model, Amazon's Prime Now service crowdsources delivery for fast service; drivers sign up to work specific time blocks, and customers pay a premium for speedy delivery.

Parcel lockers

Parcel lockers are on-site drop boxes situated at locations such as apartment buildings, supermarkets, office buildings, and shopping malls, where people can pick up packages using individual access codes sent to their mobile devices. Customers, who can select which location they prefer for each delivery, benefit from convenient 24/7 access; shippers benefit from fewer total delivery locations and fewer failed delivery attempts, saving time and mileage and reducing vehicle emissions. Used to their full potential in developed, dense cities,[9] parcel lockers can decrease labor time per parcel by 60 percent and reduce delivery costs per parcel by 35 percent (Exhibit 11).

Parcel lockers show the greatest promise in high-density cities, where it is possible to locate them in convenient areas with high foot traffic; in such instances, vehicle emissions could be reduced by up to 70 percent. If people have to drive or make a special trip to a parcel locker, as is typically the case in lower-density cities, the benefits are fewer.

EXHIBIT 11 **Parcel lockers deliver economic and environmental benefits.**



Parcel lockers, which have been around for at least a decade, have had mixed success. Instituting the system requires a substantial investment and is not suited for all kinds of parcels, such as large appliances or goods that need refrigeration. Many consumers prefer to have their packages delivered straight to their home.

That said, there is a great deal of promise. In China, the number of parcel-locker terminals is growing strongly, and such deliveries now account for about 6 percent of the total.[10] In Germany, DHL has about 3,000 terminals with almost 300,000 compartments in more than 1,600 cities and towns.[11]

To work effectively, parcel lockers need to be convenient, or people won't use them. That means placing terminals in easy-to-access locations and ensuring they are secure and simple to operate. In order to use the space most efficiently, customers can be rewarded for picking up their goods quickly—for example, through loyalty programs and discounts. Two places to watch are Japan and Singapore, whose governments are encouraging the use of parcel lockers. Japan is subsidizing half the costs to install lockers in 500 locations, chiefly train stations and convenience stores[12]; Singapore is planning a common parcel-locker system in residential areas to improve last-mile delivery.[13] In addition, a number of companies, including Amazon, PopBox, and UPS, are working hard to figure out how to cut costs and make lockers a profitable option.

Electric vehicles

Automotive companies are increasing investment in EVs; meanwhile, battery prices are falling, vehicle-emissions standards are tightening, and social cachet is rising. Inevitably, then, EVs are going to become a greater presence on global roadways. The question is not whether electrification is going to happen—it is—but how fast.

So far, most of the discussion has focused on the passenger sector. However, we believe that urban commercial delivery trucks' route characteristics, infrastructure requirements, utilization, and torque capabilities make them attractive targets for transitioning to battery power.

- **Route characteristics.** In densely populated regions, delivery vehicles typically travel predictable and relatively short routes. Given such characteristics, battery size can be optimized, minimizing cost.

- **Infrastructure requirements.** Creating a charging network for passenger cars is difficult due to the unpredictability of where and when consumers will need to charge. For medium-range commercial vehicles (CVs), this is less of a problem. They will usually not need to charge during their delivery routes and can return afterward to a local charging hub.

- **Utilization.** One of the barriers for passenger-vehicle electrification is that private vehicles are typically parked 90 percent of the time or more.[14] While operating expenses for EVs are dramatically lower than for traditional vehicles, it is difficult to create a return on their higher capital costs with such a low average utilization. Because CVs are used more intensively—typically for at least a full shift—their higher utilization can overcome the capital-expenditure-versus-operating-expense conundrum.

- **Torque capabilities.** CVs are often equipped with diesel engines because diesel's higher low-end torque performance is superior to that of gasoline engines. Electric motors, however, with their flat torque performance across the full range of motor operation, are even better than diesel engines at low-end torque.

The electrification of the commercial fleet would also provide considerable benefits to city residents. First, many urban areas are struggling with smog and pollution, which CVs exacerbate with their relatively higher emissions and longer running and idling times. There may be debate on the exact well-to-wheels emissions of EVs versus internal combustion engines, especially in places where EVs are charged with carbon-intensive sources of power, but there is no question that electrification of the commercial fleet would significantly reduce the smog-inducing NOx and particulate matter that large diesel engines emit.

Second, electrified delivery fleets help to abate noise. EVs are much quieter than diesels, especially during idle times. This could prove a significant asset in expanding night deliveries, which are discouraged in large part due to noise concerns.

Third, EVs will likely help to improve traffic flow. Conventional trucks accelerate slowly, reducing the average speed of traffic. Electric trucks, with their increased torque, accelerate more quickly.

Autonomous ground vehicle lockers

The concept is simple: self-driving parcel lockers. AGV lockers could make door-to-door deliveries or park in a location advertised to customers so they can collect their parcels. This system does not yet exist, but when it does, it could move goods more efficiently while reducing labor costs.

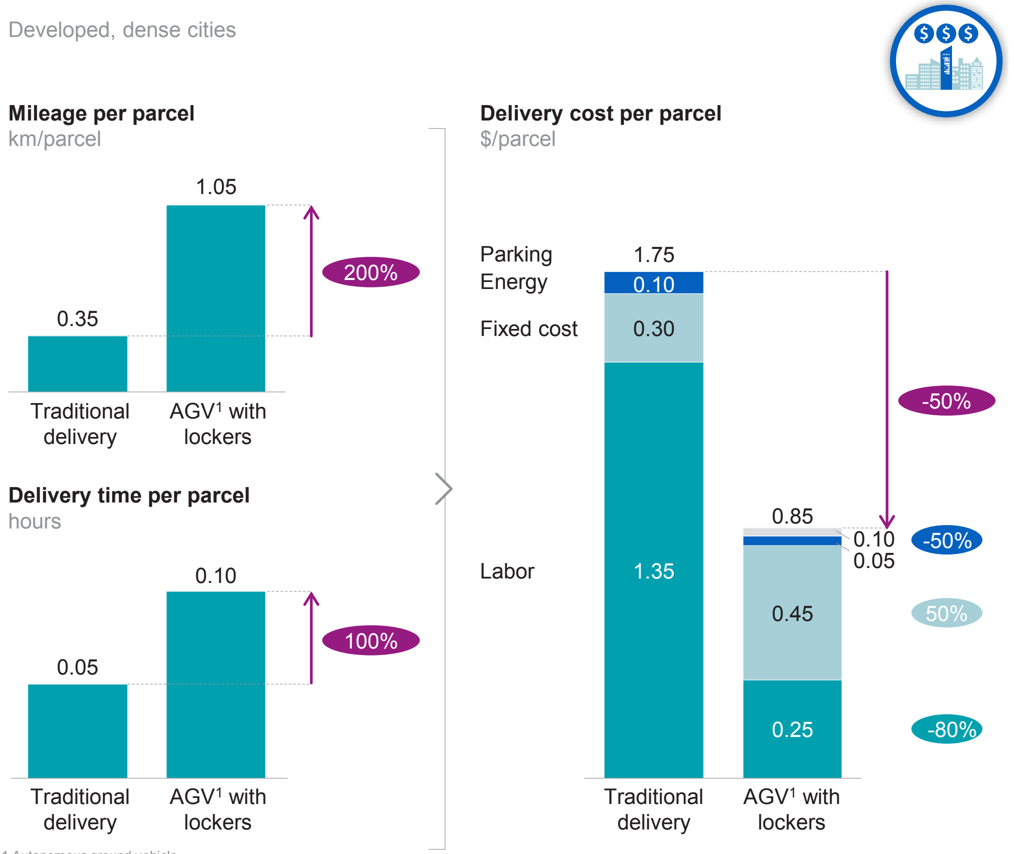
The process would work as follows: at the warehouse, parcels are loaded into each locker manually; customers are instructed how to open the locker and informed of the estimated arrival time and password. During the journey, the AGV updates customers if there are any delays and notifies them to be ready for pickup.

At the destination, there are two options. In direct delivery, the vehicle sits at the curb, and customers are expected to make the pickup. If they are late, the AGV moves on. In the second, cheaper scenario, the AGV stays in a parking lot and informs customers of when and where they can get their deliveries. The vehicle stays in the parking lot for a defined period.

Our analysis suggests AGV lockers could reduce the cost per parcel by up to 50 percent, primarily due to lower labor costs. Because AGV lockers are likely to be smaller than delivery vans, they will need to make more trips to deliver the same volume of goods; electrification is essential for environmental benefits to accrue (Exhibit 12).

EXHIBIT 12

Autonomous ground vehicle lockers reduce the cost of delivery but increase mileage.



1 Autonomous ground vehicle.

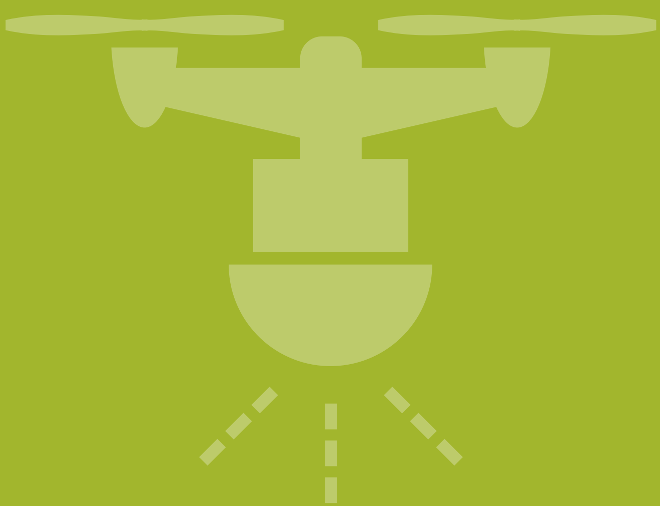
Previous McKinsey research estimated that it will take until the 2020s for AGVs to be fully functional, especially in denser urban areas.[15] There are other issues to consider as well, such as finding sufficient parking space—no small matter in many city centers. But the idea is intriguing enough that, in 2016, Google acquired a patent for AGV lockers; it has not announced a business plan.[16]

Drones

The influence of drones in the near- to midterm is unlikely to be as profound as the six solutions explored in this chapter. But interest in them is keen. Here is our analysis of the potential benefits and limitations to using drones.

In 2011, the first drone delivery attempt took place, and five years later, Amazon in Britain completed the first commercial delivery. The company has aggressive plans for the technology and recently opened a research center in Europe to develop it. Drones can facilitate delivery to areas with limited infrastructure and reduce labor costs and delivery times for small items. For consumers, drones can cut waiting times, enabling urgent or same-day deliveries.

Drones require good weather and are now limited to loads of 7.5 kilograms or less and a route of 15 to 20 kilometers. Infrastructure that will support commercial delivery is lacking, and concerns about theft, hacking, crashes, and privacy worry consumers. Finally, drones need a minimum of about two square meters to land, more than many urban households can offer.



Six ways to improve urban commercial transport

Each of these ideas can help to improve the movement of goods, unclog city streets, and reduce pollution. And when businesses and cities work together to combine two or more solutions, the benefits get even bigger—as much as 30 percent lower vehicle emissions and 50 percent lower delivery costs.

Urban consolidation centers (UCCs)

- Typically located on the outskirts of cities, UCCs are buildings where packages are brought, sorted, and dispatched. Delivery trucks are therefore loaded and routed more efficiently.
- Companies in developed, dense cities could save 25% per parcel delivery.
- Reduces delivery-related mileage up to 45%.
- Cuts vehicle maintenance costs as well as emissions of nitrogen oxide (NOx), CO_2, and particulates.

Autonomous ground vehicles (AGVs)

- "Driverless cars" that need little or no human intervention are unlikely to be widely available until the 2020s. When they are—and if they are electrified—multiple benefits exist.
- Reduces the cost per parcel up to 50%.
- Sharply cuts emissions of CO_2, NOx, and particulates, depending on electrification.
- Eases congestion, due to better navigation and driving habits.

Parcel lockers

- Secure and convenient delivery points allow customers to pick up packages 24/7.
- Saves time and mileage, because of more efficient routing and fewer failed deliveries.
- Cuts vehicle emissions as much as 70%.
- Decreases labor time per parcel by 70%.
- Reduces delivery costs per parcel by 35%.

Electric vehicles (EVs)

- Significantly reduces emissions of CO_2, NOx, and particulates, depending on degree and scale of electrification.
- Much quieter than conventional cars, which could help build public acceptance for more night delivery.
- Improves traffic flow, due to faster acceleration.

Night deliveries

- In developed, dense cities, companies could cut their delivery time in half.
- Reduces delivery costs as much as 40%.
- Cuts vehicle emissions up to 70%.

Load pooling

- An online platform matches customers who need space with those who have spare capacity.
- Reduces delivery-related mileage 30%.
- Cuts delivery costs up to 25%.
- Reduces vehicle emissions up to 30%.

02 Creating powerful integrated solutions for cities

Each of the solutions discussed in Chapter 1 could help relieve strained urban mobility systems. The benefits increase, however, when two or more are used together; the combined effect can be greater than the sum of the parts. For example, using urban consolidation centers (UCCs) and electric vehicles (EVs) together can enhance environmental benefits while reducing costs. Taking this one step further would be to combine UCCs, EVs, and night delivery.

Combining UCCs, EVs, and night delivery would increase the efficiency of the UCC fleets and shift traffic to off-peak hours. Night deliveries can also help to improve financial rates of return because companies can use larger EV trucks; they are also faster because they are operating during less-congested hours. For B2B store deliveries, this combination could cut delivery costs per parcel by up to 45 percent, reduce the number of trucks required by 60 percent, and eliminate vehicle-related emissions. This is just one example of how an integrated set of solutions can provide outsized impact. In this chapter, we examine what combinations can create the greatest effect for particular kinds of cities.

There is no single solution for cities to relieve the stresses on their mobility systems—they will need to deploy a range of solutions based on their specific circumstances.

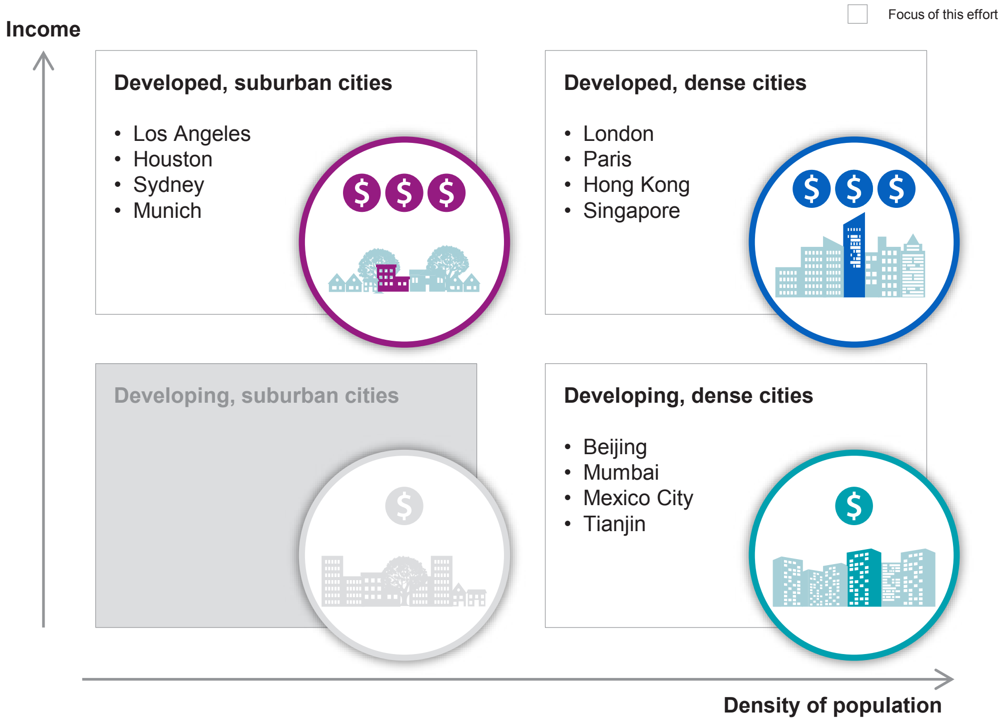
A number of the solutions we have identified, such as on-demand 3-D printing, route optimization, and EVs, can work well anywhere. Others are more site dependent. Just as different kinds of customers benefit from different solutions, so do different kinds of cities and different neighborhoods within cities. Even the best solutions will not work all the time. In the future, drones might well be a common sight, for example, but probably less so in high-rise districts because of public-safety concerns or insufficient landing space.

In line with our previous research, we focused on three urban archetypes: developed, dense cities; developed, suburban cities; and developing, dense cities. A different combination of transportation solutions will be the optimal answer for each city type. Within each archetype, we expect cities will behave in similar but not identical ways, taking into account differences in geography, demographics, labor costs, and other factors (Exhibit 13).

In **developed, dense cities** like Hong Kong, London, New York, and Tokyo, problems of congestion and pollution create a sense of urgency to make mobility cleaner and more effective. Governments and companies in these cities can afford to invest in urban planning and cutting-edge technology, and high wages favor the business case for technology-intensive solutions. In previous work, we have outlined how autonomy, electrification, and multimodal options could rapidly advance in this type of city, eventually resulting in a “seamless mobility” system.[17]

EXHIBIT 13

We expect key cities to behave similarly to one of three city archetypes, with of course a few unique variations per city.

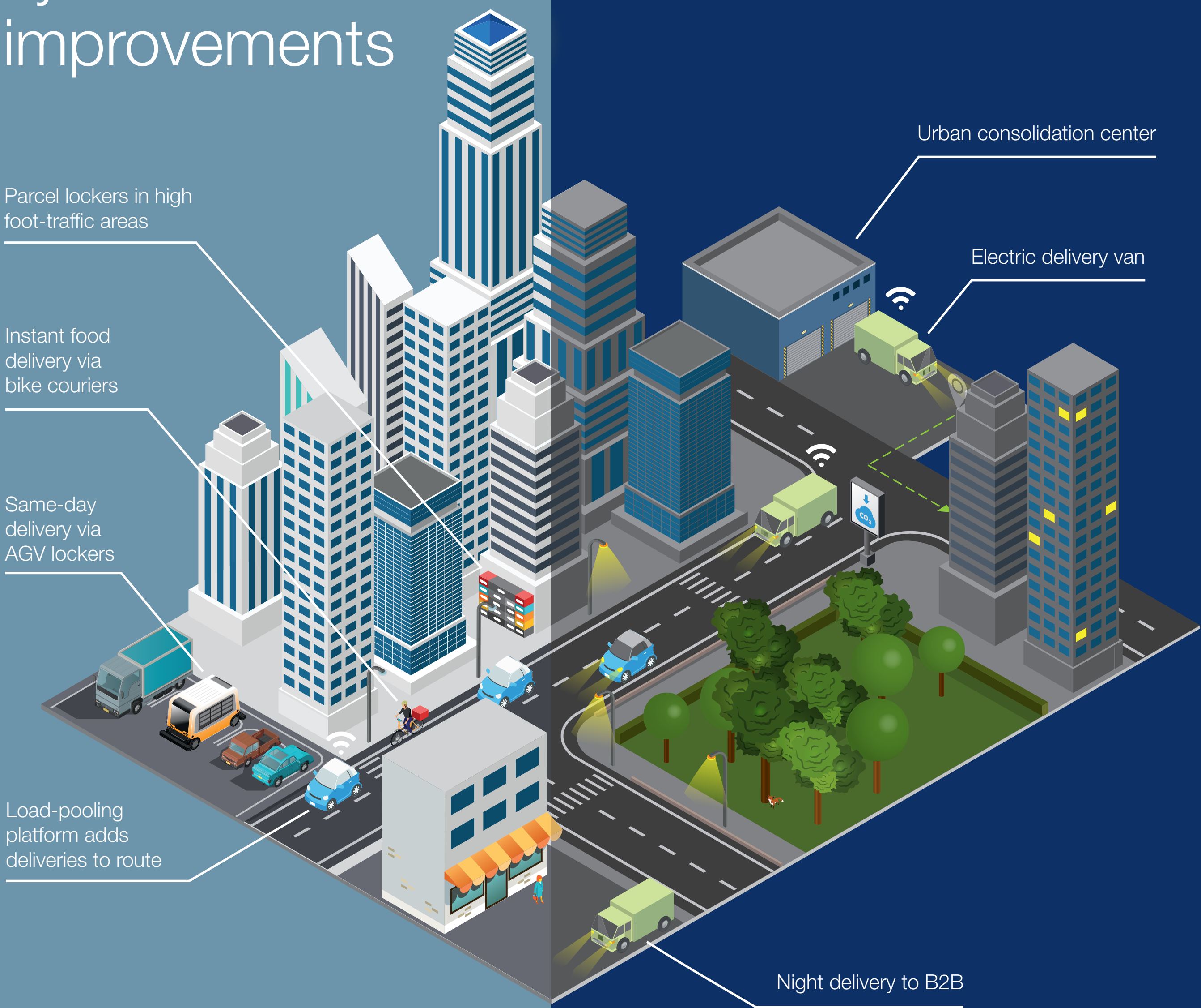


Developed, dense cities are also likely to be at the forefront of change for freight mobility, because they have both the means and the motivation to combine autonomy, electrification, and more efficient use of roads and trucks. For B2B deliveries, for example, cities are excellent prospects for combining UCCs, EVs, and night delivery. Businesses that shift to night deliveries using EVs could see savings of as much as 45 percent in delivery costs. We expect smaller businesses to lower delivery costs by using night delivery in combination with UCCs, improving average truck utilization from 50 percent to 80 percent. Larger businesses, such as grocery or retail chains, would not benefit as much from UCCs, because they can use their own warehouses.

For regular B2C deliveries in this type of city, a network of parcel-locker stations, supplied at night, is feasible because many consumers will be able to walk to them. At the moment, this is the most cost-efficient way to replace traditional home delivery. In the long term, we expect the growth in instant/same-day B2C delivery to be supported by the introduction of autonomous ground vehicle (AGV) lockers, driven to a large extent by the high labor costs in these cities.

EVs likely will play a prominent role in all these developments. Commercial vehicles (CVs) travel an average of less than 50 kilometers a day, well within the range of commercially available electric vehicles. The power infrastructure is well developed and reliable in developed, dense cities, and many of them are imposing more stringent local emission regulations.

A developed, dense city could incorporate many solutions to capture system-wide improvements

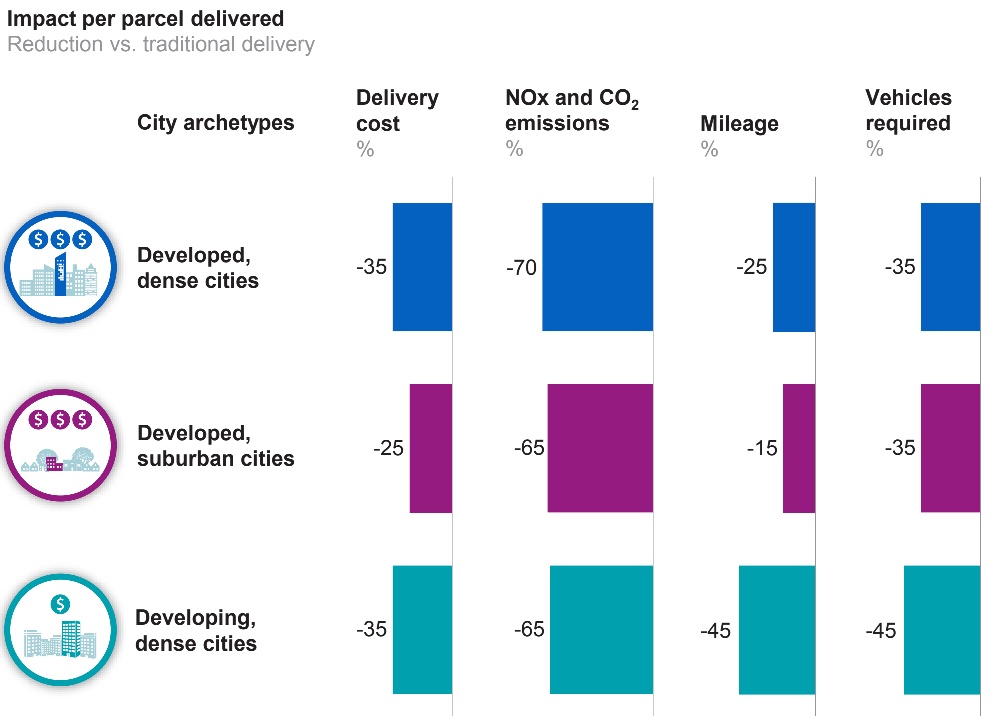


For many of these solutions to work—particularly UCCs and parcel lockers—scale is essential. When utilization of parcel lockers drops to below 50 percent, the cost savings quickly diminish. UCCs face a similar dilemma, as lack of participation reduces the benefits of delivering to the tightly clustered businesses. The preceding illustration shows how many of our solutions could coexist.

Traditional delivery methods will no doubt continue for some time. Even so, we estimate that implementing an integrated and effective set of solutions at scale in a developed, dense city could reduce delivery costs per parcel by 35 percent, cut vehicle emissions by almost 70 percent, and require one-third fewer vehicles (Exhibit 14).

EXHIBIT 14

Integrated solutions have different effects depending on the type of city.



Developed, suburban cities like Houston, Los Angeles, Munich, and Sydney, where sprawl is the norm, will need to devise a different set of solutions. In our research on individual mobility,[18] we described a future in this type of city that is characterized by "private autonomy," with high degrees of electrification and autonomy but limited sharing. A parallel can be drawn to the freight system. The use of UCCs would not be as widespread, because the distances between businesses are much greater, reducing the associated cost savings. But we still expect a shift in B2B toward electrification and night delivery. The use of EVs would bring substantial savings on fuel costs; that said, their limited range at the moment means that traditional gas- or diesel-powered vehicles likely will account for a greater share of the fleet than in denser cities.

Electric direct-to-doorstep AGV lockers will fulfil a significant share of deliveries for B2C when driverless technology matures. AGV lockers, individual parcel lockers, and truck or hand delivery will together provide the necessary location flexibility. The sprawling nature of these cities means that consumers will have to travel much farther to pick up packages than those in dense ones. For same-day and instant services, drones could eventually play a role for small, low-weight package delivery.

Combined, these solutions could reduce the average delivery cost per parcel by up to 25 percent, while reducing tailpipe NOx emissions by 65 percent. The decrease in mileage is less than in a developed, dense city, due to the longer distances and the lower consolidation potential.

Finally, we expect **developing, dense cities** like Beijing, Mexico City, and Mumbai to transition to a “clean and shared” system. Difficult roads and less sophisticated traffic infrastructure, lower adherence to traffic rules, as well as relatively low labor costs likely will slow the adoption of fully autonomous vehicles in these cities. Instead, their priorities will be to develop cleaner transportation and to alleviate congestion.

For B2B deliveries, we would expect these cities to implement UCCs in combination with night deliveries and EVs. Just as in developed, dense cities, B2C multiday deliveries could benefit from a network of parcel lockers supplied by a partially electric delivery fleet. For same-day delivery, less mature infrastructure in combination with significantly lower labor costs will likely delay the use of AGV lockers in less developed cities. Instead, load pooling will fulfil a large part of same-day delivery needs; load pooling requires no new infrastructure and so is the most efficient way to relieve congestion.

The relative benefits, in terms of delivery costs and vehicle emissions, are similar to those of developed, dense cities: 35 percent reduction in average delivery costs, and 65 percent or more reduction in vehicle emissions. With 45 percent fewer vehicles required, the impact of the integrated solution set on commercial fleet size is largest in this city archetype. While the solution set for cities like Beijing and Mumbai may be less technologically sophisticated, the starting point, regarding pollution and congestion, is also generally worse. Our analysis showed that deliveries in developing, dense cities require twice the mileage on average and result in up to two and a half times higher emissions than in developed, dense cities.

03 Knock-on effects across sectors

Changes in urban delivery systems will create new sources of competition as well as new opportunities. Five sectors will face significant change: retail, logistics, the public sector, automotive, and energy.

Retail

The retail sector accounts for a significant share of urban commercial transport. Given rising congestion and pollution, retailers will need to think about how to deploy solutions, such as night delivery and urban consolidation centers (UCCs), to supply their shops. Another factor is the shift to online retail, with more goods being delivered directly to consumers.

This creates an opportunity for retailers to differentiate their delivery offerings—with respect to speed, cost, and convenience. According to McKinsey research, about a quarter of consumers are willing to pay a significant premium for same-day delivery; about 2 percent will do so for instant delivery. Seventy percent, however, prefer to opt for the cheapest option. One intriguing insight: if consumers had to pay $3 extra for home delivery, half said they would use a parcel locker instead. Innovating on delivery options is a must: for the majority of retailers, last-mile home delivery today eats into their margins.

While using different approaches will enable retailers to bring goods to customers faster and at less cost, additional deliveries will add to commercial traffic. If not managed well, retailers may face demands to pay for the resulting congestion and pollution.

The use of different delivery solutions—parcel lockers and night delivery now, and drones, droids, and autonomous ground vehicle (AGV) lockers down the road—could help retailers to decarbonize their supply chain, limit their congestion and pollution footprint, and strengthen their competitive advantage in delivery. Faster and/or home delivery at set times would become a premium option.

Finally, getting to the “last mile”—the point of delivery—is not strictly one way. These solutions could also apply to returns, which run from 20 to 50 percent in some categories such as apparel.

Logistics

The logistics industry is poised for significant change. Especially in the urban areas we studied, the traditional model of large diesel trucks rumbling through cities and blocking traffic as they drop off and pick up packages will largely disappear. Change is coming to every step of their operations, from warehouse operations (where the current approach focuses on sorting packages for daytime delivery) to capital expenditures (where they will need to invest in fleet electrification and autonomy) to final delivery (where consumers will want a broader set of delivery options). The logistics companies that thrive will be those that push change on all these fronts.

Companies in this sector are in an enviable position. As e-commerce and commercial freight grow, so will the demand for the services of logistics companies. But the competition is also likely to intensify: venture-capital investments in urban delivery services in Europe and the United States rose from less than $200 million in 2013 to $1.7 billion in 2015—and is still going strong.[19] With so much money coming into the sector, and the emergence of new delivery methods and business models, logistics players will have to be both smart and nimble to succeed.

Though the massive scale of large incumbents' delivery fleets insulates them to some degree from some of the newer business models, there are interesting opportunities for them to adopt higher-value solutions. Chinese e-commerce player JD.com, for example, has announced plans to invest more heavily in logistics automation, including automated warehouses and drone deliveries. When provided within an efficient network, instant and same-day delivery options can create higher profit margins.

One immediate priority is digitization. To reap the benefits of load pooling and UCCs, logistics companies need to ensure that they have sound and secure predictive capacity-planning capabilities. In the longer term, as vehicle fleets become autonomous, they will have to become even more cyber-savvy, both to protect proprietary data and to prevent hacks.

Companies in this sector are in an enviable position. As e-commerce and commercial freight grow, so will the demand for the services of logistics companies. But the competition is also likely to intensify.

To make this work, partnerships will be required. Given their expertise in software engineering and their higher tolerance for exploratory investments, technology companies are the logical choice to own, manage, secure, and analyze vehicle-generated data. As aggregators and translators of data, they could provide vehicle manufacturers and operators with the insights they need to integrate vehicles, infrastructure, and data to improve such functions as load pooling journeys, traffic-flow management, and predictive maintenance.

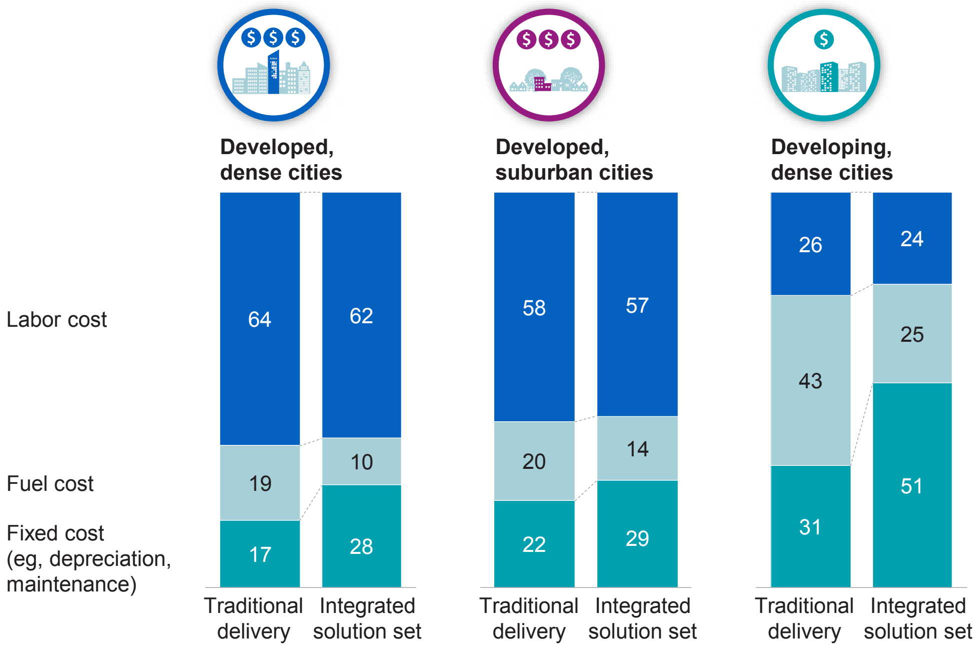
Second, assuming that the trends toward higher vehicle utilization, more deliveries during lower congestion periods, and greater use of electric vehicles (EVs) do occur, fixed costs will increase as a percentage of the total cost of B2B deliveries (Exhibit 15). This will intensify the need to manage assets well.

Finally, customer communications will become even more important. Customers must know the time, place, and method of delivery (such as droids or AGV lockers) and how to access their parcels. Because some consumers do appear willing to pay a premium for enhanced services, logistics companies that excel in these and other kinds of execution could see higher revenues and profits.

EXHIBIT 15

The share of fixed costs in delivery is likely to grow as new solutions are implemented.

Cost breakdown of B2B cost of deliveries
% of total cost per delivery



Public sector

The economic prosperity of urban areas depends greatly on the movement of goods. With commercial deliveries projected to grow by 40 percent by 2050,[20] cities are under pressure to ensure that this movement is efficient and cost effective. To that end, they can invest in infrastructure and implement incentives that keep the economy thriving while improving air quality, congestion, and safety.

Cities will play a big part in how, where, and how fast new technologies and business models roll out. Good urban planning and regulation will be a deciding factor in the ability of the private sector to capture the potential of these new models and innovations—to everyone's benefit.

Comprehensive regional planning that accommodates new transport solutions will become increasingly important as cities grow.[21] For example, devising loading docks and zones that allow delivery vehicles to go in and out smoothly will become more critical as the number of deliveries grows. Similarly, urban planning is required to accommodate UCCs and parcel-locker stations. Abandoned shopping malls and parking structures could become UCCs and warehouses. In addition, these locations are often centrally located, allowing supply chains to hold inventory closer to consumers. Repurposing such buildings for distribution could help to meet demand for fast delivery.

Governments can also minimize congestion by applying smart infrastructure that gathers data on where and when vehicles are entering cities and then rerouting traffic accordingly. In New York, where trucks deliver 90 percent of goods, the city has created the Smart Truck Management Plan,[22] which is gathering data and running experiments to improve freight operations. One pilot program shifted 20 companies to night deliveries (between 7:00 PM and 6:00 AM); this resulted in more deliveries in the same amount of time, better customer relationships, less fuel consumption, and easier access to legal parking.[23] City leaders are now looking at how to curb noise.

To reduce emissions of particulates and NOx, Athens, Madrid, Mexico City, and Paris have announced plans to ban diesel vehicles from their city centers by 2025. As the economics of EVs improve, cities may want to consider how to accelerate the electrification of the local commercial vehicle fleet. For example, creating low-emission zones, in which high-emission vehicles are excluded, could help to incentivize the shift to cleaner vehicles. If EVs are to be used more for last-mile deliveries, however, fast-charging infrastructure will need to be available.

Eventually, as described in Chapter 2, integrated solutions could sharply reduce both emissions and the number of delivery vehicles required. That will happen only if the public and private sectors work together. The more distant solutions, such as autonomous vehicles, drones, and AGV lockers, will also need governments to set the policy framework.

Automotive

The good news for commercial vehicle (CV) players is that they can expect growing volumes. Historically, the number of CVs manufactured has grown in tandem with the increase in freight volume. With the rise of e-commerce, and thus a greater number of consumer deliveries, more CVs are likely to be built and sold. The expectations of these vehicles, however, will change.

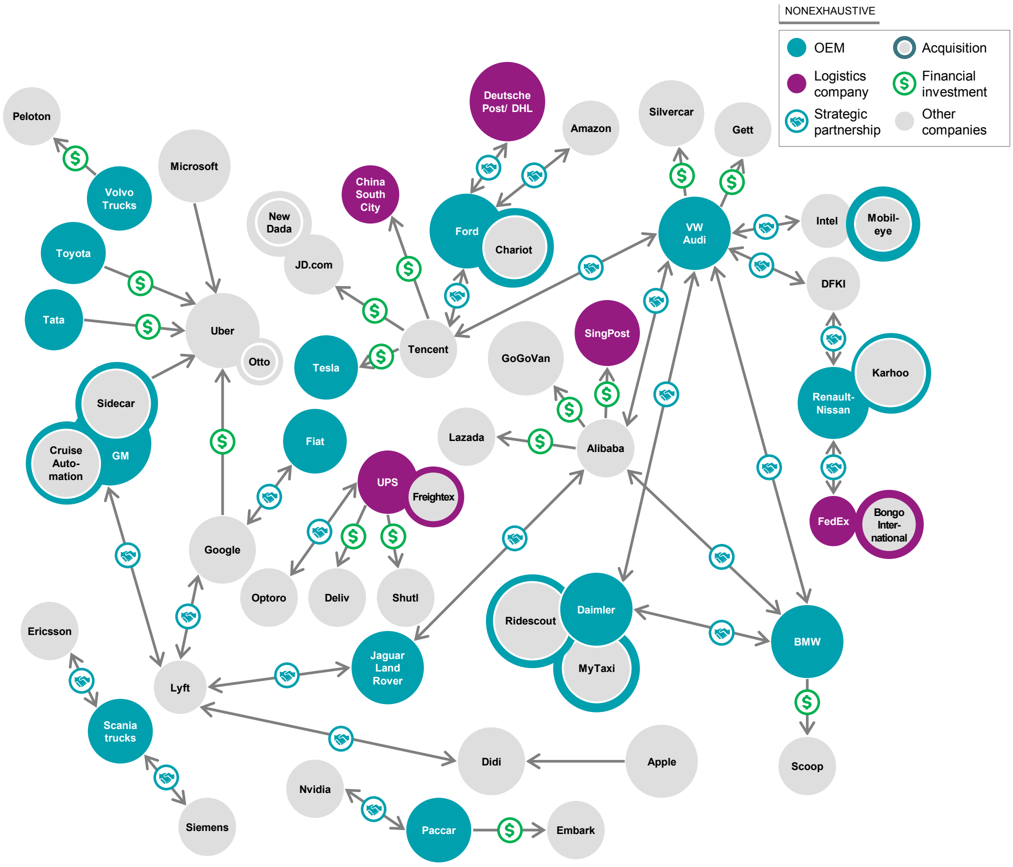
Specifically, automotive players will have to adapt to increasing electrification and autonomy. Not only will these trends affect the underlying technology of traditional commercial vehicles, but solutions such as AGVs will require development of completely new kinds of vehicles.

Finding partners will therefore be essential in advancing autonomous vehicle (AV) capabilities. Right now, algorithm defects represent most of the manual interventions that still need to be overcome to achieve a high degree of automation. Commercial AVs will be sophisticated computers on wheels, equipped with software that crunches massive amounts of data in real time to optimize routes and improve safety and reliability. A quarter of the vehicle's value will be in its software.[24] AVs will also provide a testing ground for technology companies to develop their expertise in machine learning and predictive analytics.

In a larger sense, autonomous technology needs to integrate the distinct capabilities of manufacturers, Internet companies, and other technology businesses. Players from these industries are finding themselves with both new competitors as well as new opportunities for partnership (Exhibit 16).

EXHIBIT 16

Automotive OEMs and logistics and tech players have already formed extensive partnerships.



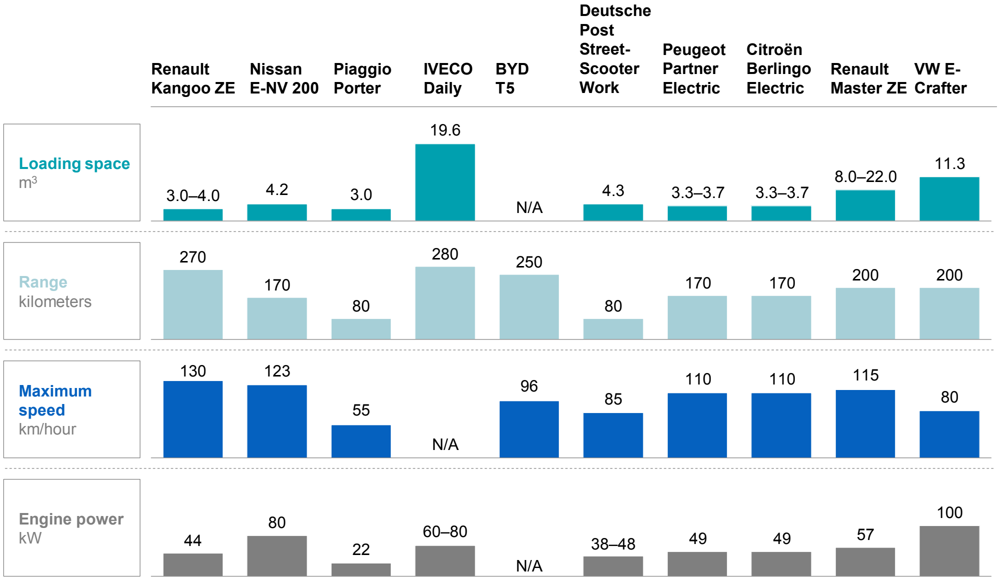
Automotive players have begun to collaborate with technology and logistics companies to deliver the next wave of passenger and freight mobility. Granted, some of these investments are related to passenger mobility, such as Lyft (GM) and Moovit (BMW). However, UberEATS, a restaurant delivery service, and UberRUSH, a pickup and delivery service, show how these platforms can be extended to commercial transport.

Although electrification of the commercial fleet can help to address noise and pollution concerns, few options are on the market. Moreover, with respect to the total cost of ownership, battery-powered commercial delivery vehicles are still more expensive than conventional ones. With higher utilization, though, the cost differences narrow and could disappear in the 2020s; the break-even point will vary from place to place, depending on a variety of factors.[25] In cities that have instituted high-cost antipollution regulations, it is already possible to break even.

As battery prices come down and as regulations—whether in the form of a carbon price or tougher fuel-efficiency and emissions requirements—drive up the need for cleaner vehicles, the demand for low-emission CVs will rise. The development pipeline needs to be able to meet this demand. Many companies are already in the market, and more are coming in (Exhibit 17).

EXHIBIT 17

More companies are entering the commercial electric vehicle market.



Source: Company websites; price lists; press search

Deutsche Post, for example, bought an EV start-up and has begun producing its own custom EV vehicle, the StreetScooter, because it couldn't find the right kind of zero-emission truck in the quantities it needed.[26] Thousands are already on the road, and Deutsche Post plans to produce 10,000 this year, making the company Europe's largest producer of electric CVs.[27]

As battery prices come down and as regulations—whether in the form of a carbon price or tougher fuel-efficiency and emissions requirements—drive up the need for cleaner vehicles, the demand for low-emission CVs will rise. The development pipeline needs to be able to meet this demand.

The economics of applying fully autonomous technology to deliveries can be attractive, and this market is already on the move. A number of players are entering the market for AGVs and have conducted trials for last-mile deliveries (Exhibit 18).

EXHIBIT 18

Companies are investing in autonomous delivery vehicles.

Manufacturer	Vehicle	Description
Ford	“Autolivery” autonomous van	Electric, self-driving van that nests autonomous drones within it; still in concept phase
VOLVO	VNL truck powered by Otto hardware	Truck with level 4 autonomy powered by sensors and hardware from Otto, an Uber-owned company; made deliveries in 2016
DAIMLER	Mercedes-Benz Vision Van	Joy-stick-driven electric van with an automated cargo loading system that can launch drones and self-driving robots; range of 270 kilometers
UPS	Hybrid electric van that can launch drones	Hybrid electric van with covered garage on roof of truck that houses drones; codeveloped by Workhorse Group and HorseFly
Google	Autonomous van with built-in parcel lockers	Autonomous truck or van fitted with series of lockers that could be unlocked with code sent to person waiting for delivery
CHARGE	Autonomous, electric delivery van	Self-driving, electric delivery van that takes only 4 hours for 1 person to build; range of 100 (full electric) to 500 (hybrid electric) miles

Other smart delivery technologies

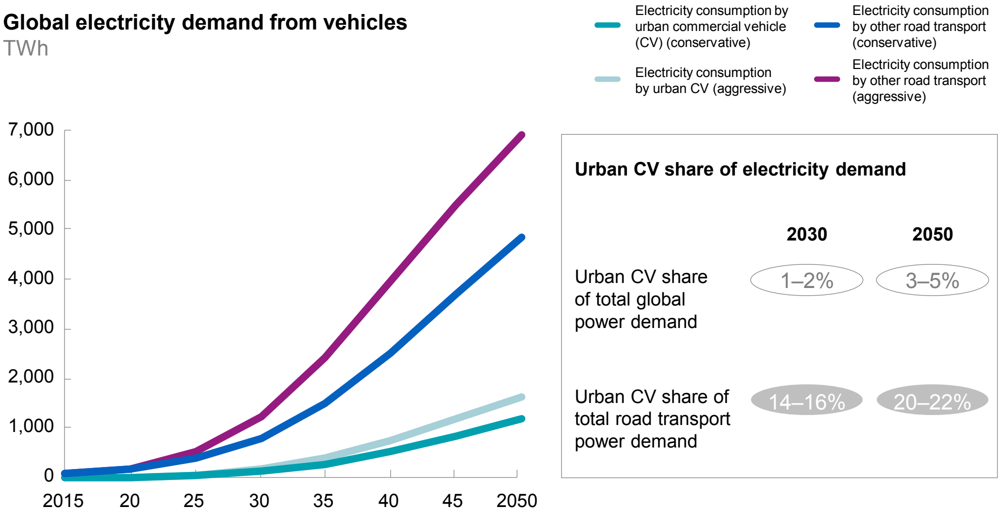
Delivery drones
- Google
- amazon
- DHL
- Flirtey
- HorseFly
- MATTERNET
- XAIRCRAFT

Delivery AGVs
- STARSHIP
- dispatch making delivery smart
- MARATHON TARGETS

Delivery crowdsourcing platforms
- UBER RUSH
- POSTMATES

Source: Company websites; expert interviews; Martin Joerss, Jürgen Schröder, Florian Neuhaus, Christoph Klink, and Florian Mann, *Parcel delivery: The future of last mile*, September 2016, McKinsey.com

EXHIBIT 19 Power demand of electric vehicles will depend on how quickly electrification happens.



Source: BNEF; McKinsey

Energy

The impact of vehicle electrification on the energy sector will depend on how fast it happens. McKinsey analysis expects up to 20 percent of urban CVs will be electrified by 2030. At that level, they would add about 2 percent to global electricity demand (Exhibit 19).

There are two major implications. First, while the global increase in electricity demand may not be large, greater vehicle electrification could significantly add to peak load demands on local grids. These demands will differ, depending on the location; utilities therefore need to understand the potential impact of EV clustering for the grid and incorporate those insights into their investment plans. Power companies will also need to be able to quickly respond to the large spikes in demand that could result from simultaneous charging of EVs. Sensors and smart controls can help them predict, manage, and respond to these spikes in real time. Collaboration with logistics companies in combination with time-of-use or locational rates could help to incentivize companies to create transparent and predictable profiles, use off-peak charging, and mitigate demands for peak power. Particularly for EVs making night deliveries, finding times to fully recharge during the day without adding to peak loads will require a deliberate approach.

Second, vehicle electrification offers new opportunities for power companies, such as providing charging to commercial fleets. The business case for this is much clearer than for public on-street chargers, but it will still be important for utilities to clarify their role with respect to both charging infrastructure and associated grid enhancements. Electric vehicles become even more attractive in environmental terms if utilities invest in renewable generation; the more low-emission sources are used, the greater the clean-air benefit.

Conclusions

Urban commercial transport in 2030 will look dramatically different than it does today. For a start, economic growth and the ever-greater use of e-commerce will increase commercial traffic of all kinds. Consumer expectations will be different, too, with more same-day and next-day deliveries. At the same time, the demand for individual mobility will increase. Without significant change in how goods are moved, the pressure on many urban mobility systems will intensify, bringing more congestion, more pollution, and more frustration.

Luckily, there are many ways to address these problems while cutting the cost and improving the efficiency of last-mile deliveries. Some solutions, such as urban consolidation centers (UCCs), have been tried but are still small scale. Others, such as autonomous ground vehicle (AGV) lockers, do not yet exist. We believe that new technologies and business models—including autonomy, electric vehicles (EVs), and the greater use of data and connectivity—will bring new options and enable approaches that haven't worked before.

Many companies are already working to reduce delivery costs, the number of vehicles on the road, miles driven, and vehicle-related emissions. But they cannot do as much as they could without government cooperation. To realize the greatest potential, there are three priorities.

First, governments need to take a comprehensive view. The success of many approaches, such as parcel-locker zones and night delivery, will depend on planning, infrastructure, and regulatory direction. Together with private investors, governments should develop a vision of a modern commercial mobility system and create a framework that encourages early adoption of solutions and penalizes patterns that damage urban life.

Second, private-sector companies will need to collaborate with regulators and each other. Retailers, for example, will find that logistics are likely to become an even more critical element in their business model. Automotive and technology players will need to combine their complementary skills to create the products and services that will define the future of urban commercial transport.

Third, both the private and public sectors need to understand that the status quo is not sustainable—and that only bold action will change it. This mind-set will enable them to scale up new technologies and solutions and to capture the additional benefits of combining two (or more) of them. Plenty of methods have been successfully tested, but change will come only when the solutions described in this report are both common and part of a well-planned set of complementary actions.

As in other areas of mobility, there is significant momentum. We believe that change will happen faster than many people expect. The unsustainable character of the current system, the pace of technological change, the willingness of urban residents to adapt to new ideas, and the inclination of governments to act are all factors likely to push cities toward a cleaner, safer, and better future.

Endnotes

[1] "Urban Development," World Bank, March 29, 2017, worldbank.org.

[2] Shannon Bouton, Stefan M. Knupfer, Ivan Mihov, and Steven Swartz, "Urban mobility at a tipping point," September 2015, McKinsey.com.

[3] Emissions from new CVs are remarkably lower, even surpassing passenger vehicles. However, given the current age of the fleet and the more intense usage patterns of CVs, they still contribute more emissions overall.

[4] "WHO releases country estimates on air pollution and health impact," World Health Organization, September 27, 2016, who.int/phe/health_topics/outdoorair/en/.

[5] "2015 Urban Mobility Scorecard," Texas A&M Transportation Institute, August 26, 2015, mobility.tamu.edu.

[6] J.H.R van Duin et al., "Understanding financial viability of urban consolidation centres: Regent Street (London), Bristol/Bath, & Nijmegen," *Transportation Research Procedia*, 2016, Volume 16, pp 61–80.

[7] "DHL reveals the sharing economy is shaking up logistics," Deutsche Post DHL Group, May 29, 2017, dpdhl.com.

[8] "UPS acquires Freightex Ltd. to accelerate expansion of UK and European truckload brokerage business," UPS, January 9, 2017, pressroom.ups.com.

[9] This assumes a 90 percent utilization rate, stations with 100 lockers, unloading time of 0.7 minutes per parcel, and an initial investment of $39,000 per station.

[10] *7 smart Express box Competition! Market share, profit model who is better?*, Express, March 2017.

[11] Eric Kulisch, "DHL increases convenience for e-shoppers," *American Shipper*, May 24, 2015, americanshipper.com.

[12] "Japan to subsidize pickup lockers to reduce parcel deliveries," *Nikkei Asian Review*, January 17, 2017, asia.nikkei.com.

[13] Patrick John Lim, "Locker system for parcel deliveries in residential areas to be implemented: Tharman," Channel News Asia, April 26, 2016, channelnewsasia.com.

[14] Paul Barter, "Cars are parked 95% of the time," Reinventing Parking, February 22, 2013, reinventingparking.org.

[15] Kersten Heineke, Philipp Kampshoff, Armen Mkrtchyan, and Emily Shao, "Self-driving car technology: When will the robots hit the road?" May 2017, McKinsey.com.

[16] https://www.google.com/patents/US8983649.

[17] Eric Hannon, Colin McKerracher, Itamar Orlandi, and Surya Ramkumar, "An integrated perspective on the future of mobility," October 2016, McKinsey.com.

[18] Eric Hannon, Colin McKerracher, Itamar Orlandi, and Surya Ramkumar, "An integrated perspective on the future of mobility," October 2016, McKinsey.com.

[19] Thomas Netzer, Jan Krause, Ludwig Hausmann, Florian Bauer, and Tim Ecker, *The urban delivery bet: USD 5 billion in venture capital at risk?* May 2017, McKinsey.com.

[20] *The 2017 MHI annual industry report: Next-generation supply chains: Digital, on-demand, and always-on*, MHI, 2017, mhi.org.

[21] Shannon Bouton, David Cis, Lenny Mendonca, Herbert Pohl, Jaana Remes, Henry Ritchie, and Jonathan Woetzel, *How to make a city great*, September 2013, McKinsey.com.

[22] "Smart Truck Management Plan," New York City Department of Transportation, nycdotfeedbackportals.nyc.

[23] "Off-hour deliveries program," New York City Department of Transportation, nyc.gov.

[24] http://www.luxresearchinc.com/news-and-events/press-releases/read/self-driving-cars-87-billion-opportunity-2030-though-none-reach.

[25] *Gearing up for growth: Future perspectives on the global truck market*, May 2016, McKinsey.com.

[26] "Elektrotransporter der Post wird zum Renner," Spiegel Online, August 8, 2017, spiegel.de.

[27] Richard Weiss and Nicholas Brautlecht, "Even Germany's post office is building an electric car," Bloomberg, March 24, 2017, bloomberg.com.

Authors

Shannon Bouton
Eric Hannon
Linda Haydamous
Bernd Heid
Stefan Knupfer
Tomas Naucler
Florian Neuhaus
Jan Tijs Nijssen
Swarna Ramanathan

Acknowledgments
This report builds on a considerable body of expertise within McKinsey.

We particularly want to acknowledge Janice Alexander, Emily Billing, Jacqui Cook, Georgia Dempsey, Alexandre Fanno, Bhavin Gandhi, Sascha Hower, Stephen Jacobson, Nursultan Khamsin, Christoph Klink, Eric Li, Jan Mischke, Timo Möller, Eric Morden, Cait Murphy, Laurence Parc, Jürgen Schröder, Yohoon Song, Tristan Swysen, Jonathan Woetzel, and Cynthia Wu.

McKinsey Center for Business and Environment
September 2017

Designed by VME
www.mckinsey.com