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Change vehicles: How robo-taxis and shuttles will reinvent mobility

Uncertainties surround the future of shared autonomous vehicles. Modeling scenarios for their development and adoption can help companies on the road ahead.

by Kersten Heineke, Philipp Kampshoff, Martin Kellner, and Benedikt Kloss

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Modern cities feature an odd mix of excitement, opportunity—and pain. Much of the latter results from getting around: sitting in traffic congestion, hunting for parking spaces, breathing exhaust emissions.

Understanding cities' problems with private cars

All cities, to a greater or lesser extent, have a problem with private cars. As an example, let's look at Los Angeles. Today, it suffers from congestion that leads to an increase in travel time of 44 minutes per day, or 170 hours per year, that are lost for every driver, making it the most congested city in the United States and Western Europe.[1] The city also aims to address car-related safety issues that it wants to solve with its "Vision Zero" target to reduce traffic deaths and serious injuries to zero by 2025.[2] Furthermore, public-transportation usage in Los Angeles is low compared with car-based mobility; additionally, Los Angeles, like most other cities, faces emission problems, heading the list of most polluted US cities regarding ozone.[3]

These challenges result largely from today's mobility situation. As in nearly all major cities in the world, private-car usage dominates LA's mobility mix, accounting for about 80 percent of all passenger miles traveled in Los Angeles County.[4] Public transportation handles only about 5 percent, while the stake of shared mobility is below 1 percent today. However, there's accelerating adoption of shared mobility in particular, driven by the rise of electric e-scooter sharing, among other factors.[5]

We believe electrified, shared autonomous vehicles (AVs)—also called robo-taxis or shuttles—could address these pain points while revolutionizing urban mobility, making it more affordable, efficient, user friendly, environment friendly, and available to everyone.

That's the dream, but the future is uncertain. No one knows today when the technology will be mature enough, when mass-market adoption might start, where it will start, whether customers will adopt it, or how fast and large this adoption will be.

However, robo-taxi and shuttle mobility have the potential to disrupt our future mobility behavior and to cannibalize many of the miles people travel each day. This could fulfill daily mobility demands but also may signal the end of mass private-car ownership—at least in high-income urban and suburban areas.

Many companies are already operating large testing fleets of shared AVs, and even more companies have announced that they will launch fleets sometime between 2019 and 2022. The companies involved range from OEMs and suppliers to tech players and start-ups.

There are, of course, many uncertainties regarding the development of shared AVs. To deal with these and to make strategic decisions, it's important to model future AV development and adoption using the most up-to-date facts and opinions, as well as a holistic set of input parameters that can be tracked and adopted over time.

Creating a shared-mobility supermodel

To reduce the levels of uncertainty surrounding shared AV mobility, the McKinsey Center for Future Mobility (MCFM) has developed a detailed and holistic model based on a thorough fact base, consumer surveys, expert estimates, and extensive discussions with relevant stakeholders. Our goal is to contextualize trends and disruptions in the overall development of the mobility market. We plan to update the model on a regular basis to incorporate the latest developments regarding technical maturity, customer adoption, regulation, and comparison to total cost of ownership of alternative modes of transport (Exhibit 1).

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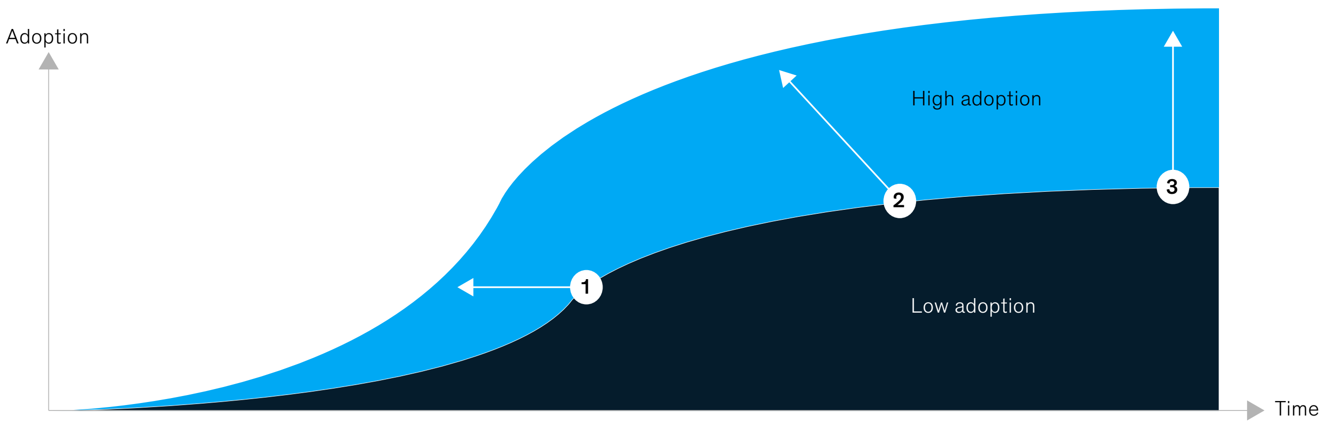
[1] TomTom Travel Index, Tom Tom, tomtom.com.
[2] "Vision Zero Los Angeles, 2015–2025," City of Los Angeles, visionzero.lacity.org.
[3] "Most polluted cities," American Lung Association, lung.org.
[4] "National household travel survey," Federal Highway Administration, 2017, nhts.ornl.gov; our analysis also draws on research from the American Public Transportation Association and the California Department of Transportation.
[5] "For a more detailed view of the micromobility market, see Kersten Heineke, Benedikt Kloss, Darius Scurtu, and Florian Weig, "Micromobility's 15,000-mile checkup," January 2019, McKinsey.com.

Exhibit 1

To quantify uncertainty over autonomous mobility solutions, we created a market model based on the observation of trigger points.

Robo-taxi adoption projection over time



1. Start of commercial launch

- Will there be regulations on a national level?
- Will the key players collaborate to build robo-taxis?

Answering yes to both could lead to earlier adoption

2. Speed of adoption

- Do customers feel safe in robo-taxis and accept a potential increase in travel time?
- Are investors willing to finance robo-taxi fleets?

Answering yes could lead to earlier and greater adoption

3. Adoption in steady state

- How are robo-taxi prices compared with other means of transport?
- Will cities support or fight robo-taxis?

Answering yes could lead to greater adoption

The model is dynamic and regionally sensitive. For example, to model future robo-taxi and shuttle mobility as accurately as possible, we took several perspectives into account. Robo-taxi and shuttle mobility will differ from city to city, for instance. Each city is unique regarding its modal split, public-transport penetration, efficiency, congestion levels, the wage levels of taxi drivers, and so on. Other factors that can differ include the cost of car ownership, the cost of parking, local taxes, city tolls, and so on. These urban markets are also unique in their robo-taxi adoption rates, rollout speeds, feasibility, and city support. Consequently, we used a bottom-up approach, introducing a city-clustering technique using city archetypes, modeling the robo-taxi and shuttle development of selected representative cities, then extrapolating the results to the global market.

Customer adoption rates for robo-taxis and shuttles will vary by mobility use case: customers will use robo-taxis and shuttles in different mobility use cases, most likely with different frequencies. To account for this, we defined more than 20 mobility use cases such as commuting, shopping, and airport transfers and took today's split and modal mix by city into account. We calibrated AV customer-adoption rates depending on the mobility use case and adjusted them by city as well. The different adoption rates depend on convenience factors, such as finding a parking space (or not) when going to the city center, and cost calculations, which depend on the next best alternative for the respective journey.

Robo-taxis will be disruptive. However, these disruptions could occur in different ways. To take these differences and remaining uncertainties into account, we modeled three scenarios per city: conservative, moderate (our base case), and aggressive.

Robo-taxis will generate new miles traveled

The model shows that introducing robo-taxis and shuttles will increase total miles traveled. Due to greater convenience, better availability, the provision of affordable mobility to people without driver's licenses, and competitive pricing, robo-taxis will generate trips and miles of travel that customers would otherwise not undertake. This increase will boost travel by about 10 percent in our base-case scenario.

Pricing will depend on today's spending for mobility. On the one hand, to be competitive and to attract as many customers as possible, robo-taxi and shuttle operators might set price levels as low as technology costs allow. Technology costs will go down over time, making shared AV mobility more affordable, which will be another driver for customer adoption. On the other hand, cities will probably not allow pricing to come close to or even undercut public-transport costs. Cities don't want consumers to avoid using public-transport offerings by switching to car-based mobility, because it would increase congestion and other urban problems. Likewise, pricing scenarios will differ from city to city, which we accounted for by investigating costs of transport at the city level and then evaluating different pricing scenarios depending on those costs.

The overall speed of adoption will depend on regional differences: the speed of customer adoption and market ramp-up will differ by region according to unique regulations, economics, and other factors. For example, higher driver costs in Europe and the United States mean that robo-taxi mobility will reach an earlier tipping point in those regions than in China, where driver costs are much lower. This will lead to earlier market ramp-up in Europe and the United States.

Applying the model to Los Angeles reveals new insights

Returning to our earlier example, Los Angeles has a head start on many cities in its acceptance of shared mobility. For instance, e-hailing services such as Uber and Lyft have taken off in the city. This acceptance will likely continue to grow over the next decade or so. The passenger miles traveled via shared mobility might increase significantly between today and 2030, rising from under a billion miles to approximately 20 billion to 30 billion (Exhibit 2).

Additionally, the introduction of potentially safer shared AV mobility options aligns with the city's goal of reducing the number of traffic deaths and serious accidents.

Applying our modeling approach in Los Angeles yields the following insights:

— In 2030, robo-taxis and shuttles could cut private-car usage by up to 20 percent compared with today in the base case, corresponding to roughly 10 billion to 20 billion passenger miles driven in Los Angeles in 2030.

— The robo-taxi revenue potential in Los Angeles in 2030 might therefore range from $4 billion to $7 billion (pessimistic scenario) up to $15 billion to $20 billion (aggressive scenario).

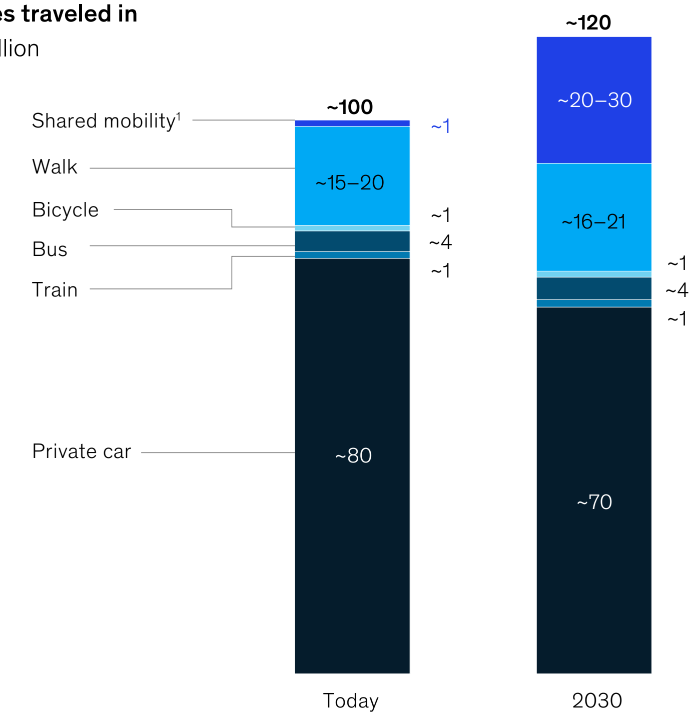
— Commuting is the most relevant use case for AV mobility services (more than 20 percent of revenue) in Los Angeles, followed by going shopping (more than 15 percent) and attending to leisure activities (more than 10 percent).

— Conversely, shared AV mobility might only slightly cannibalize public transport since the latter will remain significantly cheaper, and cities have a huge interest in shifting passenger miles traveled by car to public-transport solutions. Robo-shuttles that are pooled with several passengers have the potential to reduce number of cars on the road in the long term, maybe even in collaboration with public-transport agencies.

Exhibit 2

In Los Angeles, passenger miles traveled via shared mobility could reach nearly 20 billion to 30 billion by 2030 under base-case modeling.

Passenger miles traveled in Los Angeles, billion



[1] Includes car sharing, ride-hailing, and all other forms of shared mobility (eg, person-to-person rental, shuttle services).

Source: American Public Transportation Association; California Department of Transportation; US National Household Transportation Survey; McKinsey analysis

Beyond Los Angeles, we applied our modeling logic to several representative cities covering different regions of the world. What happens when we apply the model to Asia, Europe, the Middle East, and the United States to estimate the global robo-taxi and shuttle market potential in 2030? Does shared autonomous mobility have the potential to become a trillion-dollar market by 2030? We will reveal the answers to these questions and more in a forthcoming article.

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