



Autonomy delivers: An oncoming revolution in the movement of goods

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In last year's white paper, Islands of Autonomy, we described how autonomous vehicles would transform the way consumers move themselves beginning on the islands—those urban areas where population density, available technology, and the regulatory environment speed autonomous adoption. Consumers moving themselves, however, is only half the story of what autonomy transforms.

This year, we want to tell the other half: consumers moving goods to them using autonomous delivery. That equally powerful change in consumer behavior will lead to explosive new demand for autonomous delivery vehicles, specialized for different kinds of delivery, as well as new service businesses and new infrastructure.

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A message from Gary Silberg

In 2012, we described a new technological revolution: the rise of self-driving vehicles, whose pace of development was far faster than many realized. We focused on the impact of this revolution, how it would bring on a remarkable and exciting future that would change our lives, from the shape of our cities to the ways in which consumers moved themselves—from driving to driven. How quickly autonomy has advanced to become a part of the automobile and transportation industries, accelerated in its development by radar, lidar, and deep learning! Now, everyone recognizes that the development of autonomous vehicles will bring a sea change in consumer behavior. A future that was seen by some in 2012 is increasingly before us.

Today, we want to address another future that may seem distant but whose effects will be just as powerfully felt. It is the future of the delivery of goods that comes from the rise of autonomous vehicles and artificial intelligence. That future, we believe, will bring yet another revolutionary change in consumer behavior and transform the infrastructure of our cities still more.

We all know of the cloud, that place on the internet that stores and delivers our data at real-time speed, enabling a fantastic system for creating, processing, and communicating information. Imagine now that the shape of the cloud inspires something in the physical world, as if it leaps from the wires and circuits of our computers, networks and data farms to form a transportation system. I mean the physical cloud, which couples the tremendous capacities of computers and artificial intelligence with robotics to invent an entire delivery ecosystem. It receives orders for goods, communicates those orders for fulfillment, and delivers them via autonomous vehicles that are just starting to be imagined and will potentially number in the millions. Still more fantastic, those delivery vehicles are going to be traveling not only on the ground but through the air: drones to go with self-driving delivery vehicles. The equivalent of server farms on the Internet will be strategically located smart warehouses, fully automated spaces where goods are assembled and stored, as well as loaded by robots onto autonomous vehicles for delivery. The routes and networks for delivery on the ground will change

to meet these needs, while routes through the air will be established. That delivery ecosystem will be faster and less expensive than anything today.

Consumers will not only benefit but drive these changes to happen at an astonishing speed. It will transform their experience in a way they can't even imagine now. Driving to shop seems convenient and inexpensive, but it will be all but replaced by consumers' summoning goods to them wherever they are. Who wouldn't prefer to have their shopping wishes satisfied that easily? As the cost of such deliveries drops, consumers will rapidly adopt it. They will flock to it because it will be convenient and cheaper, and because it creates new freedom in their lives. Consumers will increasingly prefer to shop from anywhere they happen to be, simply by pushing a button on their phone, tablet, or computer.

That simple push of a button will transform the automotive and transportation industries. For so long, our industries have operated on the assumption that consumers would continue to use vehicles to shop. The shopping mission seemed to be a guaranteed form of consumer behavior, an important one, too. After all, consumers drive as many trips to shop as they do to commute. But soon, consumers will travel far less frequently for acquiring goods.

We can see signs of that future today. The rise of e-commerce at the expense of brick-and-mortar shopping is a first step away from consumers shopping by driving and

toward a future in which online shopping and delivery is dramatically more important. The development of e-commerce has already reduced worldwide the number of trips for the shopping mission.

The next step toward the physical cloud, however, will have a more dramatic effect: the autonomous delivery revolution, which will first happen on the islands of autonomy. The development of autonomous delivery vehicles will harness the change in consumer behavior e-commerce has begun and drive it forward at an explosive pace. Autonomous delivery vehicles will be far less expensive than current delivery vehicles because they will be lighter and more fuel efficient. Consumers will see their orders fulfilled far more efficiently than

results. The number of consumer shopping trips will plummet. The infrastructure that surrounds the consumer shopping mission will change radically, as retail brick-and-mortar operations become less necessary, or change to meet more specialized shopping demands.

Most important, there will be fantastic new opportunities for the automobile and transportation industries. An expansive, diversified market for the autonomous delivery of goods will appear as consumers demand that a vast range of goods arrive on their doorsteps within an hour or two—far more swiftly than in the past. That market will need different kinds of autonomous delivery vehicles to satisfy demand. Some companies are already creating such vehicles, but many

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delivery now because autonomous delivery will make use of computer networking and artificial intelligence, and delivery companies will be free of the labor costs of drivers. As a result, consumers will have the opportunity for goods to reach them in less time and with little cost, often for free.

We believe consumers will adopt online shopping wholeheartedly, which will produce transformative

of them are barely imagined at this point, such as small, nimble bots we expect will fulfill single-item orders for rapid delivery. Manufacturing those vehicles, maintaining them, building delivery systems, charging stations, and more—this is the future, an exciting and powerful one filled with emerging opportunities.

How do the automobile and transportation industries adapt to meet these extraordinary changes?

How do companies succeed in the intensely competitive environment the future will bring?

For companies to win, they cannot adopt a one-size-fits-all, global solution. Instead, they must look to the individual islands of autonomy, where these autonomous delivery markets will first appear. Companies must carefully analyze the complex markets of each island, one by one, because no two islands are exactly the same. From the consideration of each individual island, they will see the transformation in consumer behavior underway, learn what the new markets will look like, and determine how to be a player—how to survive—in this exciting if difficult future.

From the analysis of individual islands, you will be able to make the informed decisions about which markets to enter or which to continue competing in: how you will meet your own future. The revolution is coming. It's time to prepare.



Gary Silberg
Partner and National
Automotive Leader

Executive summary

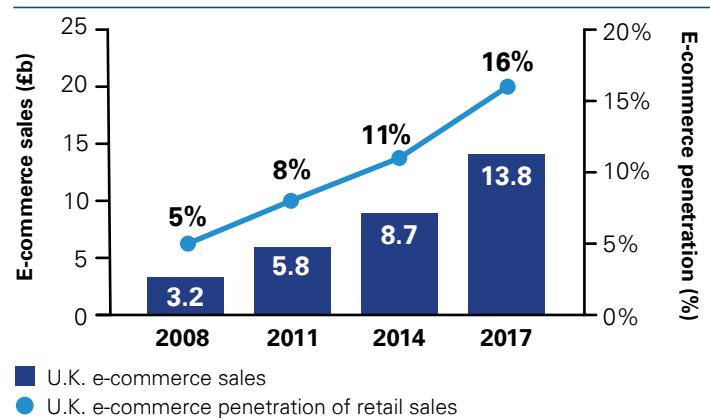


Early signs of the disruption to come

More e-commerce and fewer shopping trips

The first indication that autonomous delivery will transform consumer behavior is already here: e-commerce, a movement away from consumers visiting stores and toward ordering goods online. In the United Kingdom, e-commerce orders and deliveries, including grocery deliveries, have substantially increased while in-store shopping trips have declined along with the number of miles consumers traveled to shop. In sum, U.K. consumers are showing an increased preference for having goods moved to them.

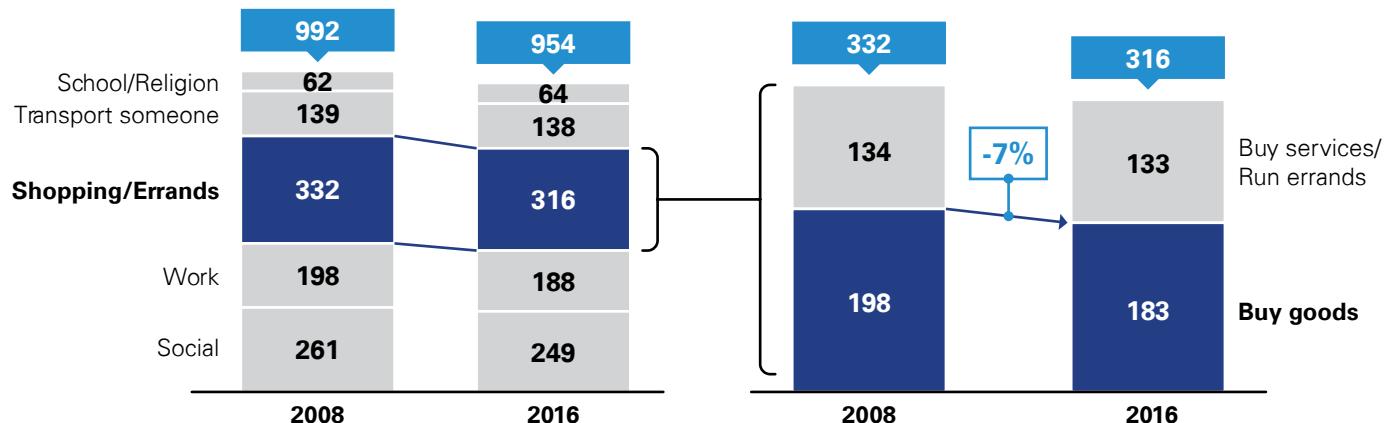
U.K. e-commerce sales and penetration, 2008–2017¹



U.K. e-commerce penetration has more than tripled in the last 10 years

Source: ¹Retail Sales Index, U.K. Office for National Statistics

U.K. annual trips per person by mission, 2008–2016¹

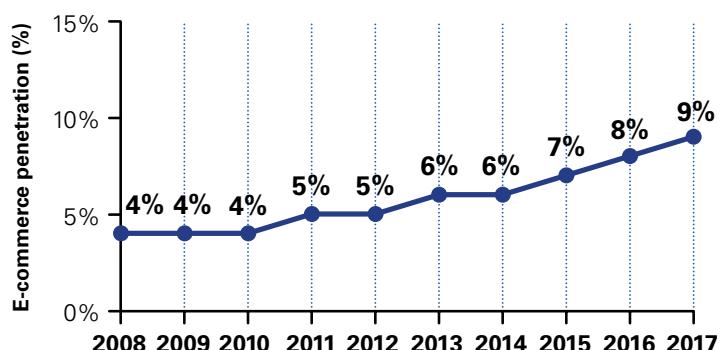


As e-commerce penetration grows, U.K. consumers are making fewer shopping trips

Source: ¹U.K. National Travel Survey (2002–2016), U.K. Department for Transport

The U.K. is only one example where the trend can be observed. China has undergone a similar shift, becoming the world's largest e-commerce market and creating some of the largest e-commerce businesses. In the United States, companies such as Amazon and Netflix have changed the retail landscape toward package deliveries, downloads and streaming. Online retail penetration in the United States has doubled in the last 10 years, and experts forecast it to nearly double again in the next⁵¹. As that penetration has increased, U.S. consumers have increasingly traveled to stores less often, and foot traffic in malls has declined.

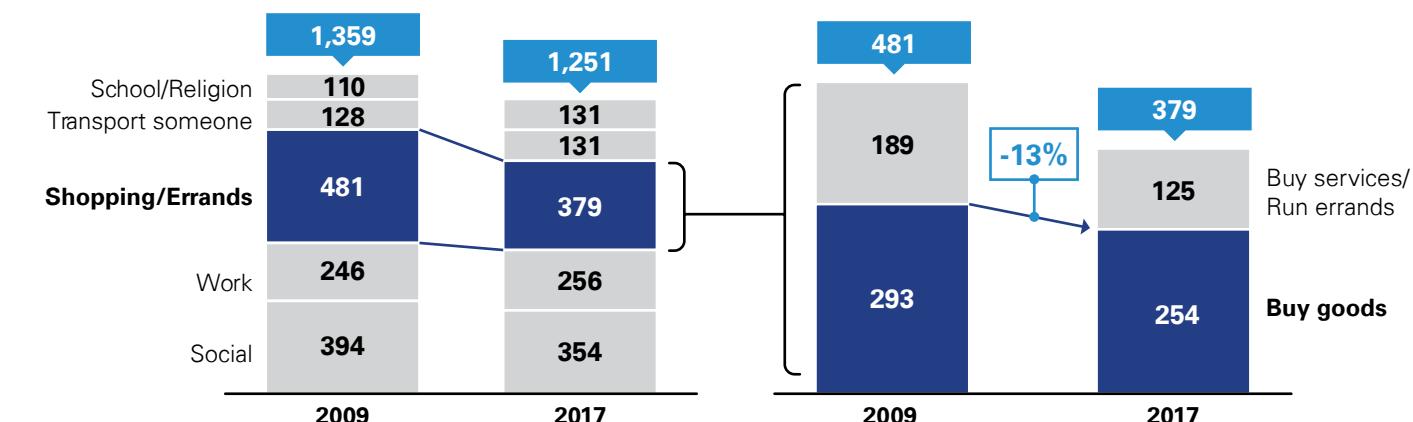
U.S. e-commerce penetration, 2008–2017¹



U.S. e-commerce penetration has more than doubled in the last 10 years

Source: ¹Retail E-Commerce Sales Report, U.S. Census Bureau

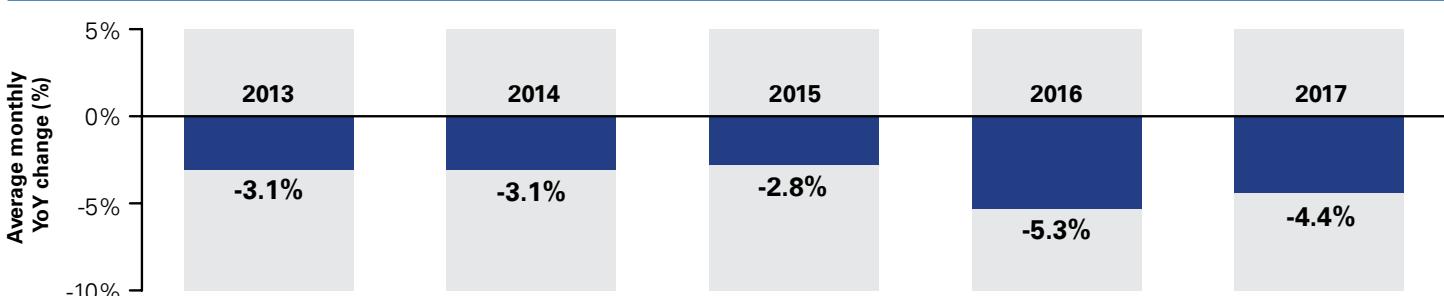
U.S. annual trips per person by mission, 2009–2017¹



As e-commerce penetration grows, U.S. consumers are making fewer shopping trips

Source: ¹U.S. National Household Transportation Survey, U.S. Department of Transportation, Federal Highway Administration

Average monthly YoY change in North America mall traffic, 2013–2017¹



Foot traffic to malls continues its steady decline

Source: ¹Department Stores & Specialty Softlines, Jefferies

¹Forrester Data: Online Retail Forecast, 2017 to 2022 (U.S.), August 1 2017, Forrester

Retail players bet on delivery

Meanwhile, a raft of related business developments in the United States signals a greater shift toward e-commerce in the future. Major retail players, including Kroger, Costco, and Walmart, are investing heavily in the technology and capabilities that anticipate significantly more online ordering and delivery². The most notable kinds of investments include the following:

- Artificial intelligence, including predictive software, which will ease the ability of consumers to find the goods they seek online and to have related goods suggested to them
- Subscription business models for goods ranging from clothing and makeup to razor blades and automobiles, all dependent on delivery, as well as providing recurring revenue for delivery businesses

- Smart warehouses to automate the storage and loading of goods for delivery, which will reduce unit fulfillment costs and make the fulfillment of orders increasingly faster and inexpensive
- Robotics to further the automation of the warehouses
- Delivery vehicles, which while not autonomous, suggest major retail players committing themselves to the importance of online shopping for their businesses

Altogether these investments indicate retail businesses betting on a future in which a far greater portion of goods are ordered and delivered.



² Marr, Bernard. "How U.S. Retail Giant Kroger is Using AI and Robots to Prepare for the 4th Industrial Revolution." Forbes, 20 Jul. 2018

Statt, Nick. "Amazon and Walmart's Rivalry is Reshaping How We'll Buy Everything in the Future." The Verge, 3 Aug. 2018

Souza, Kim. "Walmart Tests Fast Unloader in 30 of its Busiest Supercenters." Talk Business & Politics, 6 Jun. 2018

Whelan, Robbie. "Fully Autonomous Robots: The Warehouse Workers of the Near Future." Wall Street Journal, 20 Sep. 2016

Autonomy accelerates delivery: A tipping point in consumer behavior

The future, however, will not be the gradual change toward e-commerce that some retailers expect. The arrival of autonomous delivery vehicles will profoundly accelerate the shift in consumer behavior away from taking trips to stores and toward connected commerce. The price of delivery will plummet. The speed and the number of goods available for delivery will increase exponentially because of ubiquitous ordering, improved ability to predict consumer demand, and connectivity across the supply chain. And all this will happen as autonomy leads consumers to own fewer passenger vehicles. By comparison, driving

to shop will seem significantly more expensive and more inconvenient. Consumers will increasingly prefer to shop by pushing a button.

The introduction of commercial autonomy will therefore be an inflection point that leads to a profoundly new delivery ecosystem. Whether shopping from home, the office, or a college dormitory, online shopping will become increasingly favored, especially as consumers are offered a breathtaking number of options for what goods they can receive and when—within an hour, a few hours, a day, or the next day.

Some forward-thinking companies in the automotive and transportation ecospace already recognize this future. Toyota has created a self-driving delivery vehicle, the e-Palette. The start-up Nuro has designed an electric self-driving delivery vehicle for local markets.





In China, autonomy has considerable appeal as a potential leapfrog technology that could enable China to gain a leading global automotive position. Autonomous delivery is especially significant for the largest Chinese e-commerce firms. It capitalizes on their extraordinary position in the world's largest e-commerce market and solves a problem, namely last-mile delivery in its cities. Since so many of their consumers are concentrated in densely populated mega-cities—future islands of autonomy—these Chinese firms have faced difficulty delivering goods to the large number of people who live in high-rise apartments. In response, e-Commerce giants such as JD.com

are investing heavily in creating autonomous delivery. JD is already piloting self-driving robots that deliver goods to a designated location from which customers can retrieve their orders from the robot's secure e-locker. Alibaba recently introduced its own driverless delivery robot to carry multiple packages—at speeds of around 10 miles per hour—to smart lockers installed outside customers' apartments. Those lockers feature remotely controlled temperature settings for goods and are accessed using facial recognition software. Both firms are also experimenting with self-driving trucks and drones for deliveries to China's more remote areas.

Autonomous delivery reshapes the industry

All of this change will also transform the automobile and transportation industries. There will be significant demand for different kinds of autonomous vehicles to meet the diverse needs of the new delivery ecosystem. We expect there will be significant opportunities for new businesses to service and maintain those vehicles, as well as new

businesses related to the changes in infrastructure to accommodate the new delivery paradigm. These developments are the direct result of autonomous vehicles reducing delivery costs and improving delivery efficiency, which will lead to a substantial increase in delivery VMT.

Delivery gets cheap

Without drivers to pay, to carry, or to protect, autonomous vehicles will be much less expensive to produce than conventional delivery vehicles. The cost of delivery will drop precipitously. Consider, for example, the delivery cost for single-package vehicles, or “bots.” Over time, we expect their cost—including the vehicle, maintenance, fuel expenses and markup for delivery companies—to plunge to between 4 and 7 cents per mile³. That will enable retail

operations, including groceries, to make delivery nearly free: For an additional 40 cents, who wouldn’t want their stuff to arrive in an hour?

The cost of autonomous delivery will of course reduce gradually, as the expense of developing the vehicles is absorbed. But with each successive reduction, consumers will adopt online shopping and delivery in greater number and with greater enthusiasm.

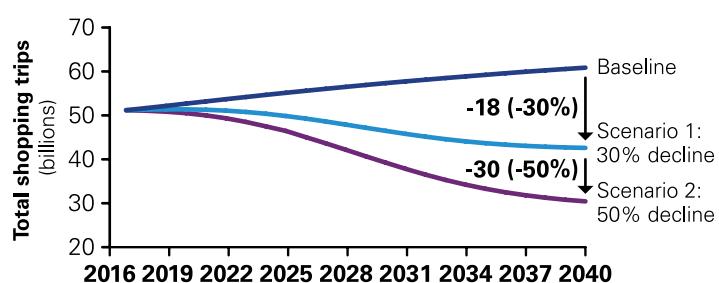
People move less, packages move more

The increased consumer demand for autonomous delivery will lead to soaring numbers of delivery VMT. That increase is the consequence of consumers replacing the trips they make to stores with delivery vehicles moving to them. In the most modest of estimates, that shift produces a large number of miles delivery vehicles must travel. At the historical rate of online shopping penetration growth—expecting no acceleration in e-commerce adoption trends—we calculate that by 2040, e-commerce would reduce the number of shopping trips in the United States by 30 percent. That is an excessively conservative estimate, however, since it ignores the increasing popularity of online shopping and the effect of autonomous vehicles entering the delivery market. A more realistic but conservative estimate is that by 2040, the number of shopping trips would reduce 50 percent.

Low-cost, convenient delivery, however, does not simply replace the decreased number of shopping trips with a corresponding number of online orders. The convenience of pushing a button will lead to greater frequency in orders and online deliveries. By our estimates, that increase in ordering frequency ranges between a factor of 1.5 to 3 times. As a result, VMT for all goods skyrockets.

The 30–50 percent range of shopping trips decline would increase VMT for all goods, including groceries, between 23 and 78 billion miles on an annual basis. And yet it is entirely possible that the cost of rapid delivery drops faster than expected, in which case the increase in VMT would be significantly greater.

U.S. one-way shopping trips (billions), 2017–2040^{1,2,3,4}



Billions of shopping trips displaced by e-commerce

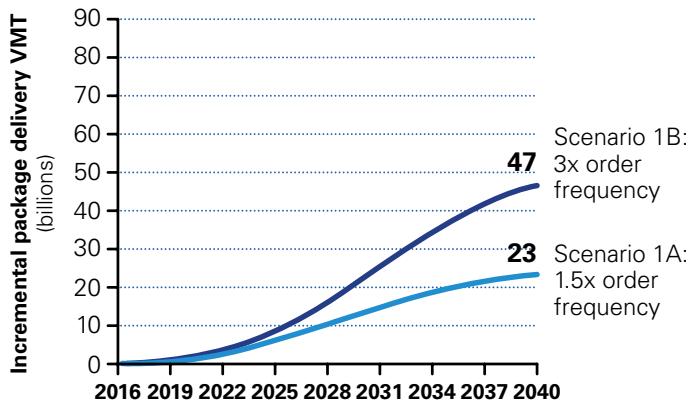
Sources: ¹U.S. National Household Transportation Survey, U.S. Department of Transportation, Federal Highway Administration; ²2017 National Population Projections, U.S. Census Bureau; ³KPMG analysis

Note(s): ⁴Baseline shopping trips determined by taking today's shopping trips per person and applying population projections

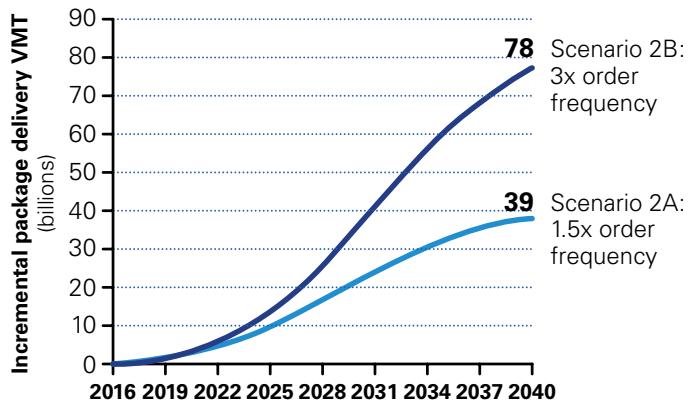
³Assumes \$1,500 to \$2,500 in upfront cost, 15,000 delivery miles a year, 5-year life, and 20 percent profit margin. Assumes no cost for parking or tolls.

U.S. incremental package delivery VMT (billions), 2017–2040¹

Scenario 1: 30 percent decline in shopping trips



Scenario 2: 50 percent decline in shopping trips



Package delivery VMT skyrockets as e-commerce displaces shopping trips

Source: ¹KPMG analysis



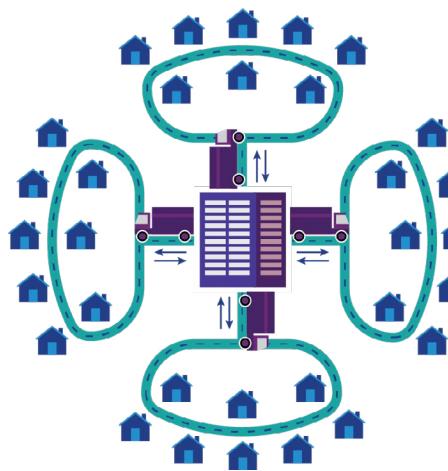
New vehicles, new services, and new infrastructure

Meet the bots

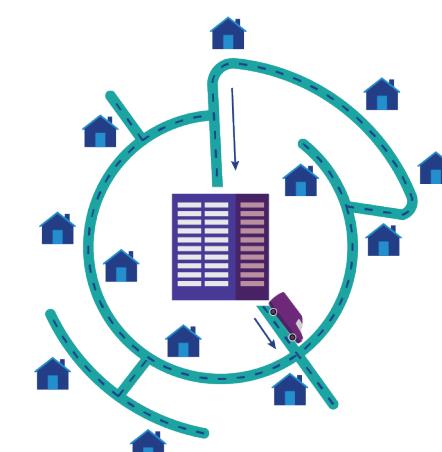
The delivery market will segment according to the urgency of delivery—a one-size-fits-all approach to building autonomous delivery vehicles will not succeed. We expect the greatest demand will be for delivery vehicles to service a significant expansion of the most urgent delivery market—goods to be delivered within the hour.

Offered the option to order items and have them delivered swiftly and nearly cost-free, consumers will seize it for an astonishingly wide range of goods, groceries included: a carton of milk, a loaf of bread, as well as cosmetics, medicines, documents, dry goods, technology, tools, clothes, and dry cleaning.

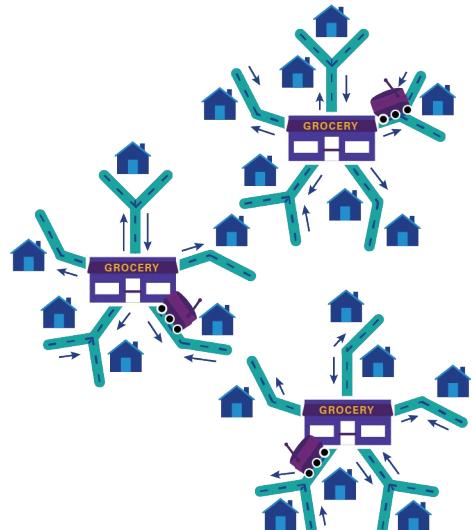
Next day delivery



Same day delivery



Same hour delivery



- Larger vehicle with many packages
- High route density and efficient route planning

- Smaller van with fewer packages
- Unpredictable volume, less route efficiency

- Bots with 1 or 2 packages
- Single or a few pooled customers served by out-and-back trips



The number of bots needed to service such deliveries will be impressively large. In most cases, a single vehicle will serve only a single order. There may well be vehicles that pool such orders, but to meet that level of urgency, they will not carry many packages to many customers. All such vehicles must travel from the store or delivery center to the consumer and return, and they will likely not move fast since they will need to unload at homes, perhaps navigating sidewalks. As a result, only a significant number of these vehicles can meet the totality of consumer demand for the same-hour delivery market.

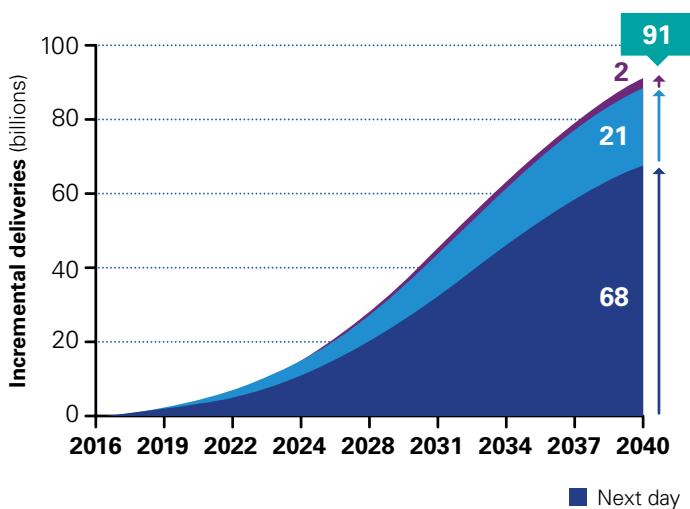
By our estimates, that demand will require anywhere from 300,000 bots on the road, if shopping trips decline by 30

percent, to 1 million if shopping trips decline by 50%.⁴ To put these figures in perspective, 300,000 vehicles is the equivalent of the number of taxis⁵ in the entire United States, and 1 million is the equivalent of the number of buses⁶. It would take only a modest increase in consumer preference for connected commerce to send vehicle demand for bots into the millions.

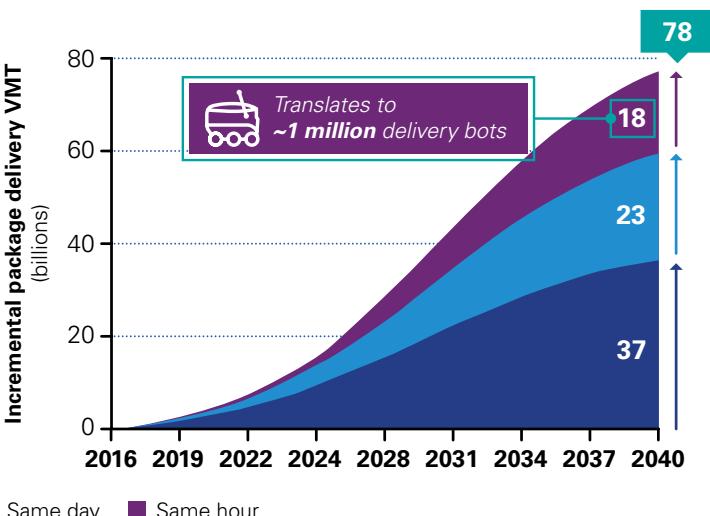
There will also be increased demand for autonomous delivery vehicles to meet the same-day or next-day delivery markets. The vehicles serving these markets—perhaps vans or trucks—will be able to contain packages for many consumers and make multiple stops.

Scenario 2B: 50% shopping trip decline and 3x order frequency

Incremental deliveries by response time (billions), 2017–2040¹



Incremental package delivery VMT by response time (billions), 2017–2040¹



Urgency drives miles—up to 1 million bots fulfilling same-hour deliveries

Sources: ¹KPMG analysis

⁴ Assumes 15,000 annual miles

⁵ Occupational Outlook Handbook, US Bureau of Labor Statistics

⁶ National Transportation Statistics, Bureau of Transportation Statistics, U.S. Department of Transportation

The autonomous delivery market will in turn create new businesses for servicing the new vehicles. The potential range of businesses is wide but includes maintenance, cleaning of vehicles, parts, insurance, and licensing. How companies will differentiate their services—whether by bundling them or focusing on one or two services, for example—will matter a great deal to their success.

A changing infrastructure creates new opportunities

Private infrastructure

Some of those new businesses for the automotive and transportation industries will relate to changes in private infrastructure that the new delivery ecospace creates. We expect that autonomous delivery vehicles will be electric, especially the bots serving urban areas. Those bots will require charging stations and facilities for cleaning them. Wherever consumers order—their homes, offices, and dormitories, among other places—there must be containers for the goods the vehicles deliver, the equivalent of technologically sophisticated lockboxes, reminiscent of the milkboxes an older generation once saw by their doors.

The Old is New: Re-birth of the milk box?



Public infrastructure

Beyond business opportunities for the automobile and transportation industries, the arrival of autonomous delivery vehicles will dramatically affect the public infrastructure in ways that cannot be entirely anticipated. The smaller autonomous delivery vehicles will require sidewalk accommodations, or the creation of new lanes or parking

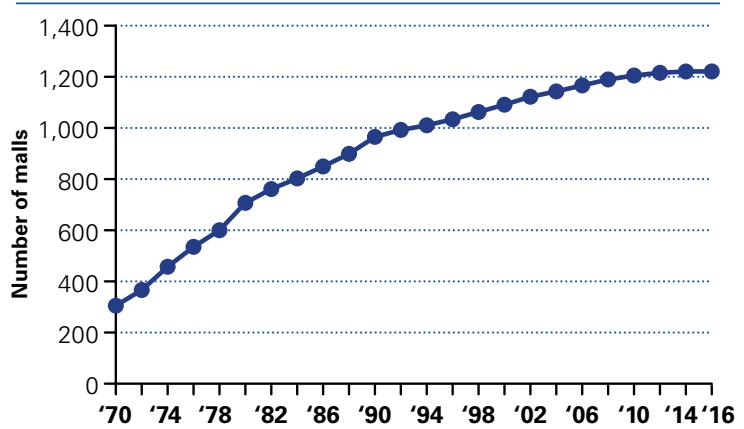
zones so that, while loading and unloading goods, they do not impede traffic. Parking on the streets will change as delivery becomes more efficient. Behind all these visible changes, there will be invisible ones, powerful computing and networking to connect this new delivery ecosystem.

A changed environment for brick-and-mortar retail

Brick-and-mortar retail will also undergo significant change. With the introduction of autonomous vehicles, the shopping mission will become far less frequent and far more specialized. In the United States, for example, we already can see collateral effects on brick-and-mortar retail from the consumer shift toward online shopping. The construction of new malls has stalled while many existing malls are being repurposed for specialty stores or for usages other than shopping. Big box stores are no longer anchor stores in malls and are rapidly declining in number⁷.

Even if e-commerce achieves 50 percent or more of market penetration, however, consumers will continue in some manner driving to shop. It may be the shopping mission survives in such specialized form as visits to farmer's markets and other experiences that are part of an "experiential economy," where shopping may become less the focal point and more ancillary to an experience: A customer travels primarily for eating or entertainment but also shops. The Costco food court, or events at the food court, may become the primary draw, the shopping secondary. The disruption in brick-and-mortar retail fuels questions more than answers at this moment, chief among them, how will retail innovate in response to the disruptions that autonomous delivery causes?

Number of malls in the U.S. 1970–2016^{1,2}



Peak mall? Credit Suisse projects 20-25% of remaining 1,200 malls will close by 2022²

Sources: ¹International Council of Shopping Centers; ²Credit Suisse

⁷ Sanburn, Josh. "Why the Death of Malls Is About More Than Shopping." Time, 20 Jul. 2017

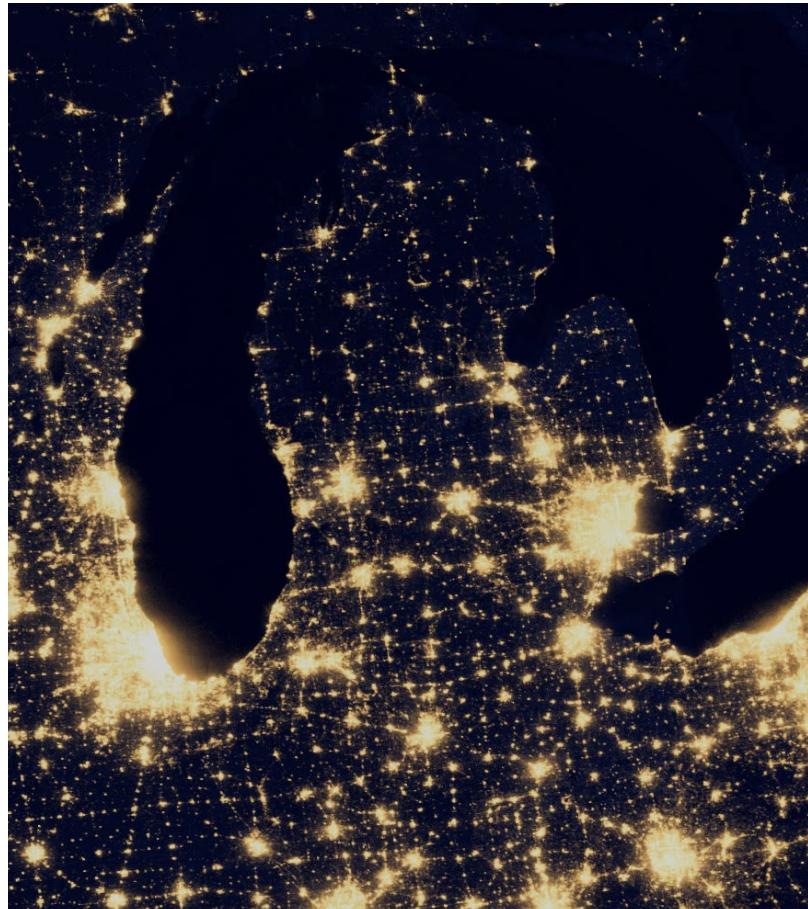
Sanicola, Laura. "America's Malls Are Rotting Away." CNN Business, 12 Dec. 2017

Preparing for the autonomous delivery future: Analyzing the islands

For the automotive and transportation industries, the consumer shift toward the autonomous delivery of goods will create potentially lucrative, highly complex, and intensely competitive markets related to the manufacture of autonomous delivery vehicles and emerging markets for related services. How should the automobile and transportation industries respond?

Look to the islands, analyze one by one

Above all, the industries must anticipate where the changes in consumer behavior will appear and how the markets will be defined. Those delivery markets cannot be understood in some wholesale way, a one-size-fits-all global or national solution—not if a business wants to succeed. Instead, as we have advised in our previous paper, companies must look to the islands, those urban areas where population density, available technology, and the regulatory environment speed autonomous adoption⁸. That is where the autonomous delivery markets will first emerge and where companies can best understand how to compete.



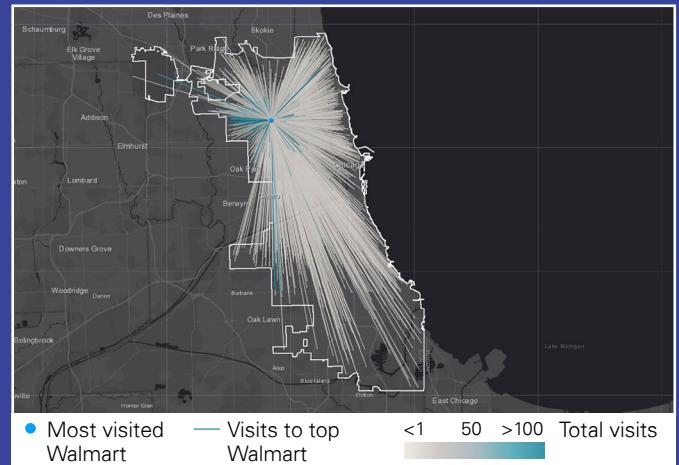
⁸ Islands of autonomy

The automotive and transportation industries must make complex, island-by-island analyses. The disruptions on the island of Chicago alone will require intense thought and research. For example, the longer mileage trips Chicago consumers take to Costco may survive the shift toward online shopping while the shorter mileage trips to Walmart and Target may be replaced by autonomous delivery. These and many other such analyses will be part of the calculations to determine the size and shape of the vehicle market in Chicago. Los Angeles–San Diego, however, may well be different from Chicago. On the Los Angeles–San Diego island, short-distance travel requires a great deal of time because of traffic congestion. That characteristic of its island likely means a strong consumer preference for the most urgent delivery services. The dynamics of the Los Angeles–San Diego island therefore mean the island may require a significantly different mix of delivery vehicles than Chicago.

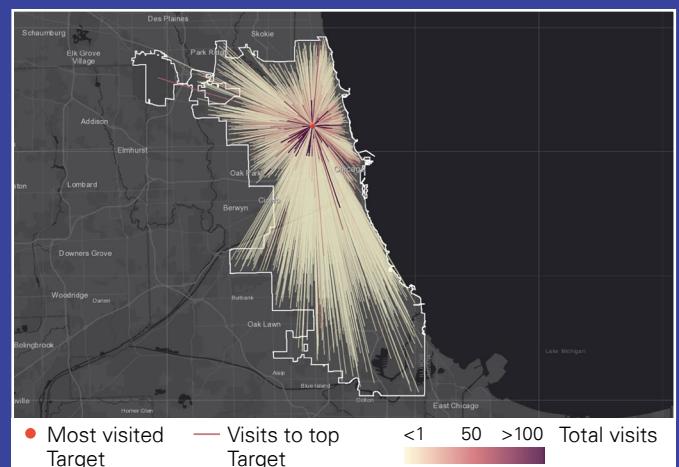
Only by such an individual island-by-island focus can the automotive and transportation industries be competitive in the aggregate or on selected islands. Only via island-by-island analysis can companies determine whether to manufacture delivery vehicles, what markets to enter, and which service to provide.

Rich data analyzed by island¹

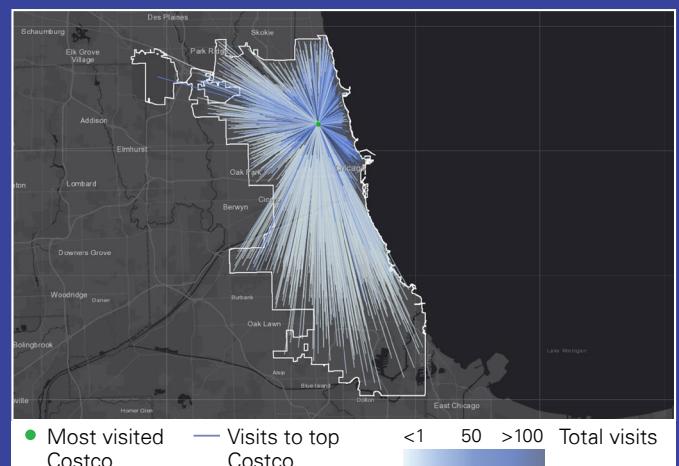
Walmart store trips in Chicago²



Target store trips in Chicago²



Costco store trips in Chicago²



Sources: ¹KPMG analysis of SafeGraph cell phone location data

²Represents consumer shopping trips from April 2017 to October 2018 to most frequently visited Walmart, Target, and Costco stores

KPMG: Our role in your decisions

As consumers increasingly turn toward connected commerce—away from traveling to shop and toward same-day and even same-hour delivery—automotive, logistics and retail players must reassess their businesses. They must recognize the transformations in the retail market and the emergence of a new and complex autonomous delivery market, including the need for autonomous vehicles, services, and private infrastructure changes. That understanding of the markets will demand both considerable data and powerful analyses on each island, to determine how and where to compete successfully.

It will include the following:



Sensing emerging business models, technology options and market segments to understand where value can be created



Refining and scaling a winning portfolio of products and services



Identifying high-value investment theses centered on “unmet needs”



Developing national roll-out strategies that reflect the needs of metro-market islands



Launching business ventures rapidly to develop and test the market



Establishing a global strategy that takes into account market evolution, maturity and island needs

KPMG can help you explore your options and create successful strategies. We can help you determine the timing and planning for specific delivery vehicles and related businesses, island-by-island. We can help you with island-by-island logistical planning and new value chain analysis to determine where you can be profitable. We stand ready to do so in this time of powerful change.

About the authors



Gary Silberg

Gary is the national automotive leader at KPMG LLP (KPMG) as well as the global lead partner for two major automobile companies. With more than 25 years of business experience, including more than 14 years in the automotive industry, he is a leading voice in the media on global trends in the automotive industry. Gary advises numerous domestic and multinational companies in areas of strategy, mergers, acquisitions, divestitures, and joint ventures. For the past five years, he has focused on the intersection of technology and the automotive industry, with groundbreaking research on driverless cars, connectivity, and mobility-on-demand services.



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Todd is a principal in KPMG's Strategy practice. He has more than 25 years of experience in strategy and corporate. He currently primarily serves the automotive industry, providing consultation services to passenger and commercial vehicle original equipment manufacturers (OEMs), Tier 1 suppliers, and emerging players in the industry.



Bala Lakshman

Bala is a Managing Director in KPMG's Strategy Practice, with more than 18 years of experience in helping companies develop their growth strategies. He specializes in the automotive sector and primarily works with automotive OEMs, tier 1 suppliers, and investors. His work has focused on helping clients plan for the inevitable disruptions in automotive including vehicle autonomy, mobility on demand, connected vehicles and electrification.



Nehal Doshi

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Thank you

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