

# Distraction or disruption? Autonomous trucks gain ground in US logistics

As logistics goes digital, profound changes are coming to industry structure, operations, and profits. In the first of a series, we examine the impact of autonomous trucks.

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Technology has upended one business after another across the United States. To cite only the most recent developments: Lyft and others have utterly changed personal transportation, and Airbnb has done the same for hospitality. And in January 2018, the first Amazon Go store opened, sans checkout clerks, promising similar upheaval for grocers.

What is happening is fairly well understood, if initially underestimated. Digitization and other technological advances are exposing the vulnerabilities in every industry, particularly retail. And now, logistics companies are starting to feel the heat. Our new research has turned up five trends that offer startling indicators of impending change for the trucking, rail, warehousing, and logistics companies that move America's merchandise.

Start with *autonomous trucks (ATs)*, which will change the cost structure and utilization of trucking—and with that, the cost of consumer goods. Sixty-five percent of the nation's consumable goods are trucked to market. With full autonomy, operating costs would decline by about 45 percent, saving the US for-hire trucking industry between \$85 billion and \$125 billion. The big question is how this savings will be distributed. How will shippers and carriers divide the lower costs of logistics? Or will most of the surplus move to consumers, in the form of lower prices?

The sustained acceleration in *e-commerce* continues to catch shippers by surprise. Today, between 12 and 15 percent of all purchases in the United States are made from the comfort of home. Amazon's same-day delivery service is only a couple of years old, but already, up to 5 percent of all its deliveries are same day. By 2025, that figure might be as high as 15 percent, cementing customers' expectations for fast and free delivery.

*Automation* at every step of the supply chain is expanding logistics firms' ability to flex with peak demand, take on heavier cargo, and pick and pack

individual products—all attributes that will support e-commerce. The industry is shifting toward comprehensive automation through projects such as XPO Logistics's "warehouse of the future," with collaborative robots, an advanced sorting system, and indoor drones. We expect that, as automation proceeds, logistics costs might fall by up to 40 percent.

*Asset sharing* is familiar to everyone who has stayed in an Airbnb home. We now see the same behavior in B2B environments, unlocking unused capacity in capital-intensive assets, such as trucks and warehouses—and even trains and ships. Already, last-mile crowdsourcing models, such as Amazon Flex, Australia's Shipster, and other supply-and-demand-matching platforms, are making their presence felt, particularly in the less-than-truckload industry.

Finally, leading shippers and carriers are using *data and analytics* to forecast demand and optimize their routes in ways we couldn't imagine even a few years ago. Some shippers have trimmed inventories by up to 75 percent, cut warehousing costs by 15 to 30 percent, and reduced administrative costs by 80 percent. Even some already-efficient third-party logistics (3PL) firms are finding that, in some cases, new routing powered by connectivity and analytics can produce efficiencies of up to 25 percent. Developments in mobile internet, the Internet of Things, and other technologies are not only increasing the data available but also helping reduce risk.

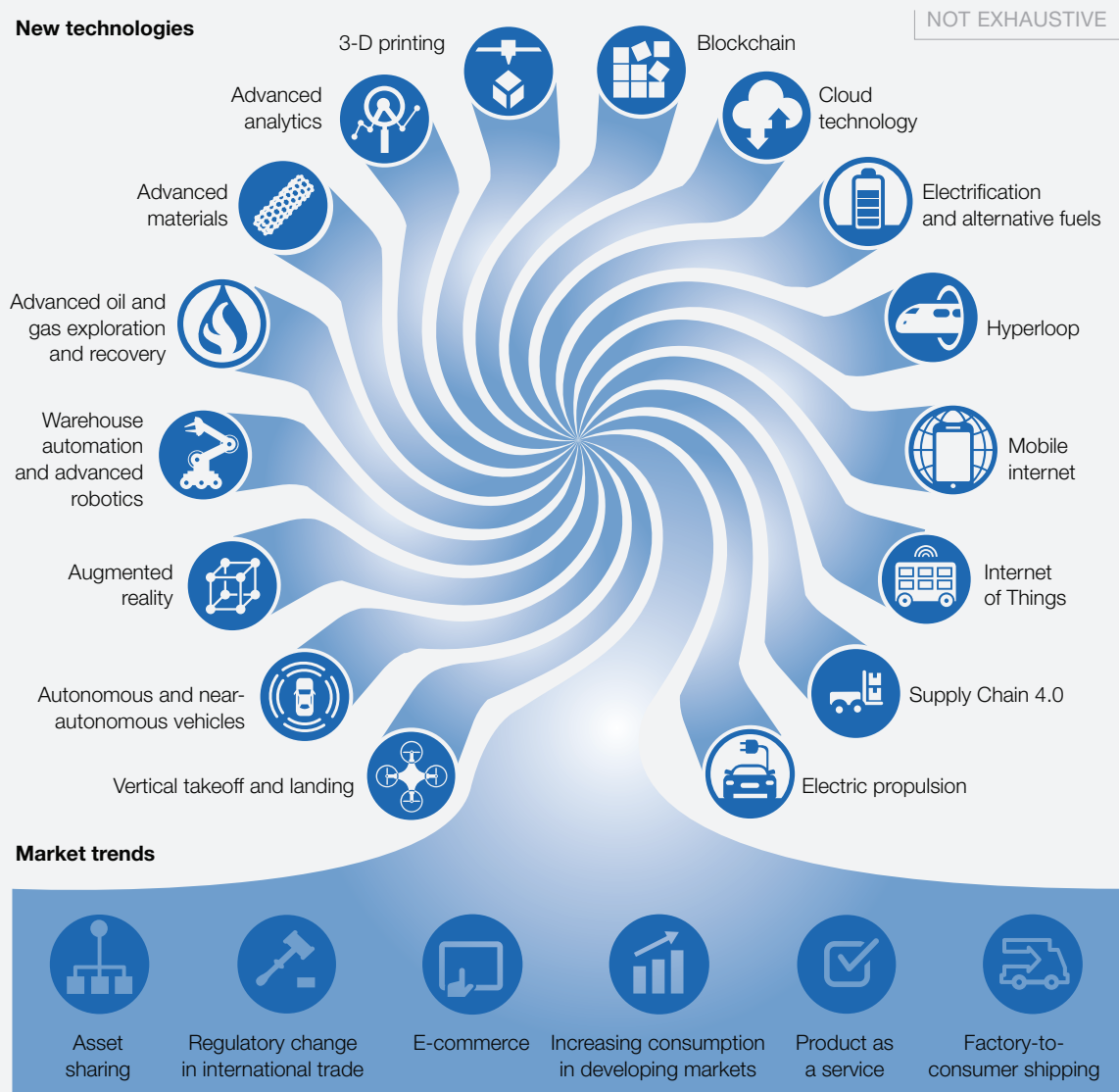
### Fast forward

Any one of these five trends might—*might*—seem like a distraction. But taken together, these shifts clearly imply disruption across the logistics business system—trucking, rail, port, and warehousing. To stay ahead, executives should ask strategic questions, such as, how might disruptive trends affect their companies? When will these trends begin to impact customers, suppliers, and revenue streams? Do the trends present threats, opportunities, or both? And how can companies prepare?

While there are no easy answers to these questions, it is possible to identify the range of potential outcomes and define clearly where to take action. In our experience, a good first step is to brainstorm the potential sources of disruption, both technological advances and market changes,

looking out ten years or so. For the logistics industry, new technologies include everything from mobile internet to hyperloop, while market changes include shifts in global trade flows and regulation. Exhibit 1 shows a sample of the trends worth considering.

**Exhibit 1 New technologies and market trends can disrupt the logistics industry.**



Source: McKinsey analysis

The next step is to narrow down to a short list of trends that will happen soonest and exert the greatest impact. As a guide for the logistics industry, we have short-listed the five trends previously mentioned, though any company in this industry might come up with a different list, depending on its subsector and its circumstances.

In a series of articles, we will address the impact of one trend and the associated actions to take, subsector by subsector, to stay ahead of disruption. In this article, the first of the series, we describe the upheaval caused by ATs and the actions each player might take first to determine and quantify the impact (negative or positive) to the business, and then design initiatives to mitigate risks and make the most of opportunities.

### ATs: Disruption on wheels

Trucking is deeply woven into the national fabric. The industry moves about two-thirds of all goods shipped in the United States. Truck driving is the primary occupation in more than half of all US states. And the industry is deeply traditional, with few major or structural changes in the preceding decades.

That's all about to change. Already, companies have made fully autonomous beer deliveries and struck alliances to operate ATs jointly. The rigs these companies are using are typically new medium- and heavy-duty trucks, outfitted with lidars, sensors, and other technology to allow the vehicle to operate without human intervention. Basic versions of the kit cost as little as \$30,000; high-end packages might cost \$100,000.

Full autonomy is a long way off, however. Our colleagues at the McKinsey Center for Future Mobility have researched<sup>1</sup> the likely development of ATs, which can be best understood in four waves (Exhibit 2). Each wave will lower operators' total cost of ownership (TCO)—a little at first, and then a lot.

The first two waves will feature “platooning,” a technique to connect wirelessly a convoy of trucks to a lead truck, allowing them to operate safely much closer together and realize fuel efficiencies. Platooning with drivers, the first wave, will still require a driver in each truck (SAE International calls this Level 3 autonomy, or “conditional automation”). Over the next three to five years, networks of these connected convoys will develop, utilizing algorithms to link up. With better aerodynamics that lead to fuel savings, these convoys could reduce the TCO of a truck by roughly 1 percent.

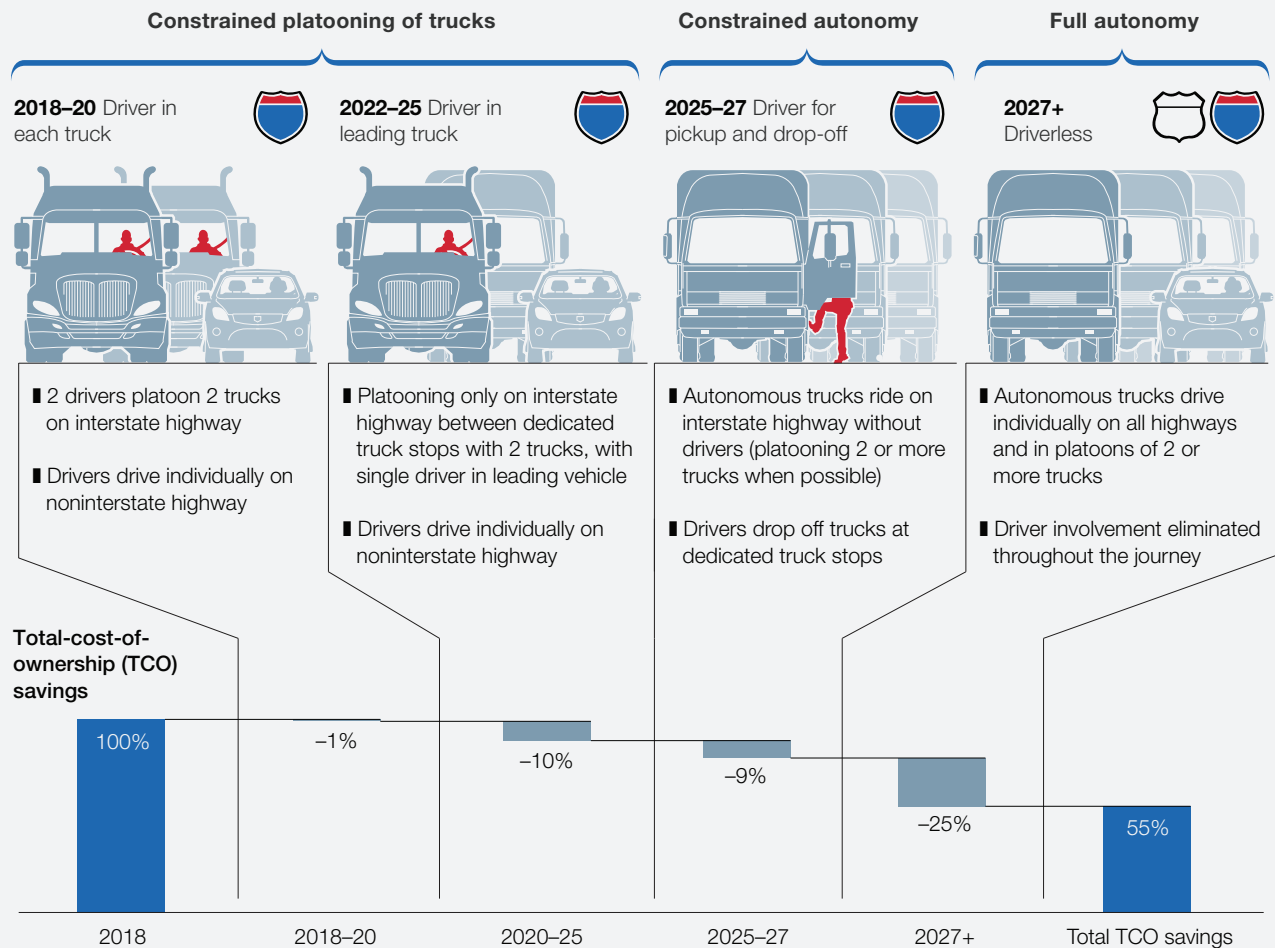
In about five to seven years,<sup>2</sup> the next wave, driverless platooning, will take hold. On interstate highways, these platoons will feature a driver in the lead truck and unmanned trucks following close behind. Upon leaving the highway, drivers will resume control of each vehicle. We estimate that the savings in fuel and labor will cut TCO by an additional 10 percent, though savings will be dependent on the proportion of highways and surface streets in the route. In every wave, long-haul routes (which have more highway miles) will offer greater savings.

In roughly seven to ten years, we expect a third wave of AT development: constrained autonomy (SAE International calls this Level 4 autonomy). Unmanned trucks will operate throughout the interstate-highway system and other “geofenced” areas without a platoon, subject to weather and visibility conditions, and developments in infrastructure such as the ability to communicate with traffic lights. Drivers will meet the trucks at the interstate exit and drive them to the ultimate destination, navigating city streets, local and pedestrian traffic, parking lots, and loading docks. This constrained autonomy will produce total savings of about 20 percent.

More than ten years from now, we expect the first fully autonomous trucks, operating at scale without

## Exhibit 2

### Autonomous trucks will likely roll out in four waves.



Source: *Route 2030: The fast track to the future of the commercial vehicle industry*, September 2018, McKinsey.com

drivers from loading to delivery (Level 5 in the SAE International framework). These ATs will reduce today's TCO by 45 percent—though it will take many years for the autonomous fleet to displace the nonautonomous national fleet.

#### Assessing the impact

Lower costs are only the most obvious of the effects of ATs on the trucking industry—and trucking is the

industry that will be most obviously affected. But ATs, like the other four trends, will send out ripples that will set new forces in motion throughout logistics. Our research, including interviews with dozens of industry executives and a review of technology-adoption patterns in other industries, suggests that cost structures, consumption patterns, and operating models everywhere in logistics will shift.

In this section, we lay out some thoughts for each logistics subsector on the implications of ATs and the ways it might respond. Trucking will be the most affected subsector, and we will examine ATs implications on it in detail in the next section. Across all sectors, each company's agenda will differ, depending on its circumstances.

### Railroad operators

For rail carriers of intermodal goods, ATs can become a fierce competitor or a valuable partner. (Non-intermodal goods such as crops, chemicals, and coal will be less affected by ATs.) We may see a shift in volumes from rail to road as the cost of trucking declines and the point of parity for shippers' costs between rail and road extends from today's 500 miles or so to nearly 1,000 miles. But there is also an opportunity. If railway companies can seamlessly integrate with ATs, they could overcome the handicap of their fixed footprints by extending into drayage, and even beyond. In so doing, rail could dramatically increase speed and throughput as well as secure a critical and growing role in the overall ecosystem. In making these strategic decisions, rail operators will also have to consider their positions on highway funding through subsidies and taxes, since more ATs will further stress the capacity and maintenance needs of the interstate-highway system.

### Warehouse, distribution-center, and fulfillment-center operators

Warehouses, as well as distribution and fulfillment centers, will experience game-changing impact. First, ATs will simplify (and reduce the cost of) 24/7 operations—a shift that will become more common as warehouses and fulfillment centers automate more of their operations. E-commerce fulfillment will move faster (though at some cost), as picking and shipping will be possible not just through the day but also at night, during shifts that are hard to staff with people. Second, ATs will reduce per-unit costs of warehousing through the ability to turn inventory more quickly.

Warehouses will likely need to invest in infrastructure changes, such as AT-compatible entrances and docks, to ensure seamless connections. Operators might be able to relocate warehouses to more remote areas as the cost of transportation falls. Alternatively, operators might be able to apply transportation savings to urban locations, improving their ability to meet rapidly growing demand for fast and free delivery.

Warehousing companies will want to ensure that ATs have easy highway access to their facilities. They might explore, perhaps with local governments, ways to limit surface traffic. The layout of parking lots should be reviewed with ATs in mind, as should dock access. And companies will want to assess their ability to provide local drivers for wave-two autonomy.

### Port operators

Ports will experience similar changes, as operations speed up and costs fall. Intermodal facilities, for example, will need to be always open to accommodate ATs. But impact on ports will be even more substantial than on warehouses. Many ports, such as Melbourne, already use AT technology to haul containers from the dock to the yard. Typically, these yards are active for only a few hours a day. But with ATs, yards can stay active around the clock. Further, with advances in ATs (and in engines—hydrogen power might help in that area), a port's activities might extend deep into the country it serves. The port's boundary might be defined by the delivery range of an AT that can seamlessly enter the roadway system rather than by a property line.

Those are long-term changes. For now, ports will need to play a more active role in ensuring smoother trucking-traffic flows—especially those ports with known bottlenecks and those in heavily congested areas. Operators might need to expand gate infrastructure and to consider alterations and expansions to highways, underpasses, and bridges. This will require support from governments, of

course, which typically recognize the economic value of shipping hubs.

### Brokers

By themselves, ATs are unlikely to have a significant effect on the brokerage business. However, the technologies that enable ATs could introduce significant new opportunities. Consider that today's trucks are typically less than 60 percent utilized, as many operate with excess space in trailers or run empty backhauls. The constant connectivity required to operate ATs—with telematics providing real-time information on location, route, and available capacity—creates opportunities for brokers to monetize capacity that goes unused today. (We'll cover this in greater detail in a forthcoming article on asset sharing.)

On the other hand, big swathes of the current trucking market are likely to become more concentrated. As we have seen in the market for ocean freight, consolidation might reduce demand for brokers, who should monitor these developments closely.

### Shippers

Shippers should consider the widespread ramifications ATs will have across the supply chain. Most notably, ATs will largely eradicate the cyclicity of supply chains, a feature created by human calendars. With ATs able to work 24/7, supply chains will be continually active, and daily, weekly, and monthly variations will likely disappear. This will change the shipping and production schedules for factories and warehouses, as shipments will be planned around efficiency considerations rather than, say, the availability of drivers. Warehouses will likely need more employees during off-peak hours to receive and send goods. These changes will reverberate throughout supply chains, causing them to operate with more efficiency and less slack.

### What will ATs mean for the trucking industry?

Naturally, trucking companies will be most acutely affected by this technological shift. Trucking is

an enormous US industry, though not without some problems. As ATs take to the highways, we see four main implications for today's trucking companies. First and most obviously, ATs will cut operating costs—though capital expenditures will rise, which could alter companies' balance sheets. Second, the rise of ATs could spur consolidation of the national fleet, which is highly fragmented today. Third, ATs could alleviate the industry's capacity crunch. And finally, ATs could create an opportunity for truck OEMs to move downstream and enter transport markets.

To be sure, the path forward for ATs is not assured; the pace of development will greatly depend on several factors (see sidebar, "Setting the pace of disruption"). As carriers evaluate these factors, they will need to decide how and when to react as well as the roles they will play. Some companies will invest early to test and learn, spending substantial R&D dollars along the way. Others will be fast followers and invest as the business case develops. Still others will wait until the technology is widely available and clearly cost advantageous.

### A robust industry ...

US trucks carry more freight than do all other modes—including rail, pipeline, water, and air—combined (Exhibit 3). In 2016, US trucking companies collected \$260 billion in revenues, or 20 percent of the worldwide total of \$1.2 trillion. Other US freight carriers collectively had \$145 billion in 2016 revenues.

In 2016, about 3.7 million heavy-duty<sup>3</sup> trucks were in operation in the United States, a figure that has grown by about 2.2 percent annually since 2011. The industry employed about 1.8 million drivers. That's ten times more than the country's Class 1 railroads, which employed approximately 165,000 people in 2017.

### ... with a capacity crunch

Even so, the industry could use more drivers, hence the "drivers wanted" stickers on the back of every

## Setting the pace of disruption

Autonomous trucks (ATs) are not assured a smooth passage. The following four sets of factors will influence the rate of AT adoption:

- **Technology.** Current testing indicates that ATs are ready to be deployed in many standard environments but not yet ready to handle uncommon “edge” cases (such as construction sites). While recent incidents have shown that the algorithms and sensors have room to improve, deep learning (an artificial intelligence technique) will improve the software with each mile driven.
- **Economics.** Economically, ATs could be more than 1.5 times more expensive than conventional trucks, requiring a higher initial investment by trucking companies and assurance of the total-cost-of-ownership savings.
- **Regulation.** The US regulatory environment has been favorable, though not comprehensively; small regions are advancing faster than others (exhibit). There is little legal precedent on the nature and extent of liability for an unmanned vehicle, creating concern for OEMs, owners, operators, and even nearby drivers.
- **Infrastructure.** US highway infrastructure is already in need of repair and expansion, with interstates near any major city clogged for hours each day. Ultimately, ATs can reduce congestion by traveling closer together, but our modeling shows that they would need to replace more than half of the national fleet to realize that benefit. Additionally, “platooning” might require depots to assemble convoys. Public or private highway-access points would also ease the path to full autonomy.

trailer. The American Trucking Associations estimates that the driver shortage, currently 63,000, could increase to 174,000 by 2026. Demography is a prime factor in the shortage. Truck drivers are, on average, about seven years older than the typical American worker. As they retire, they are not being replaced. Younger generations are opting for less-demanding careers in other industries.

Recent rule changes are also having an effect: hours-of-service regulations and the electronic-logging-device mandate have limited the number of hours that a driver can be on the road. Runs that used to take a single day now take two, effectively limiting the supply of driver hours and decreasing available capacity. Difficult working conditions and stiff competition have resulted in annual attrition rates

near or exceeding 100 percent, which have resulted in increased cost for carriers and rate increases for shippers.

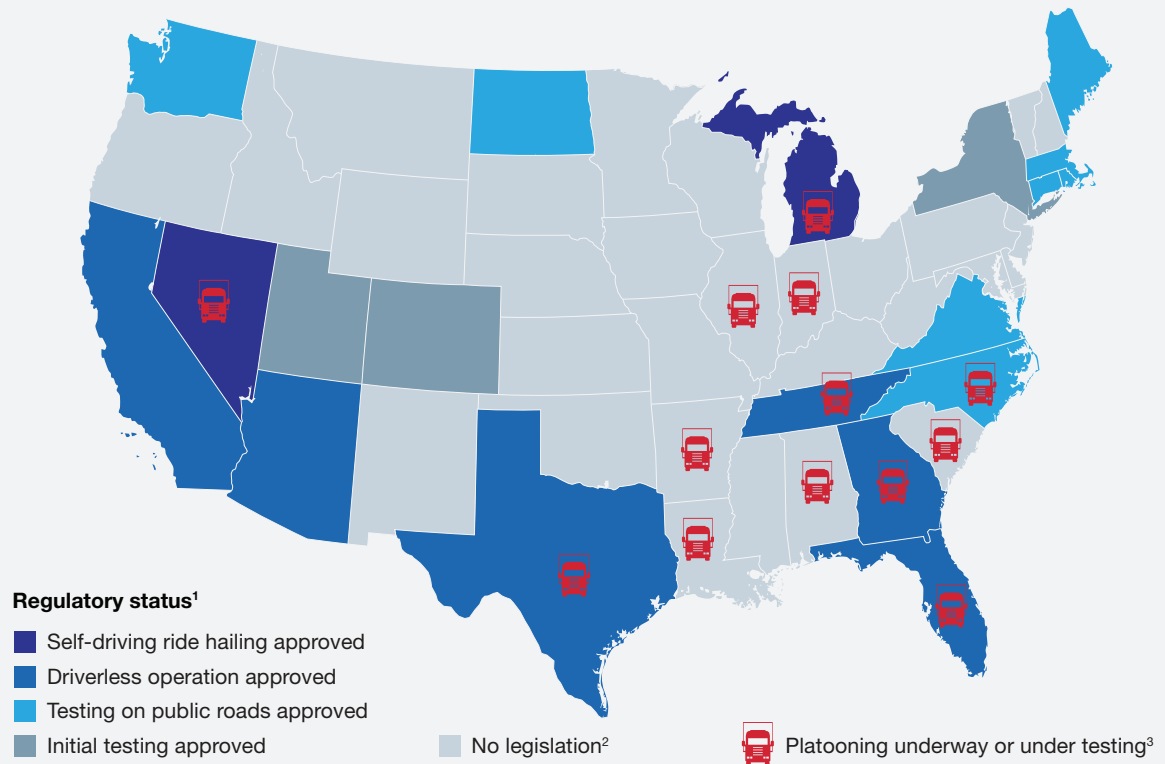
The capacity crunch has been felt across the country. Shippers often have a hard time finding carriers, which have become more selective about the loads they take, choosing those with the best margins. These dynamics have propelled an increase in long-distance truckload rates, which were 6 to 7 percent higher in September 2018 than a year earlier (Exhibit 4).

### Operating costs down, asset prices up

For the first of four implications of ATs, consider the changes in operating costs, detailed in Exhibit 2. Initial savings will be small. But we estimate that,



**Exhibit Autonomous-truck regulation varies widely from state to state.**



<sup>1</sup> As of May 2018.

<sup>2</sup> Executive orders have been issued by some states (eg, Arizona, Delaware).

<sup>3</sup> Vehicles equipped with platooning systems may follow other vehicles closer than traditionally allowed for trucks.

Source: States' public websites

with full autonomy (what we call the fourth wave) arriving sometime in ten to 15 years, TCO will fall by 45 percent from today's costs.

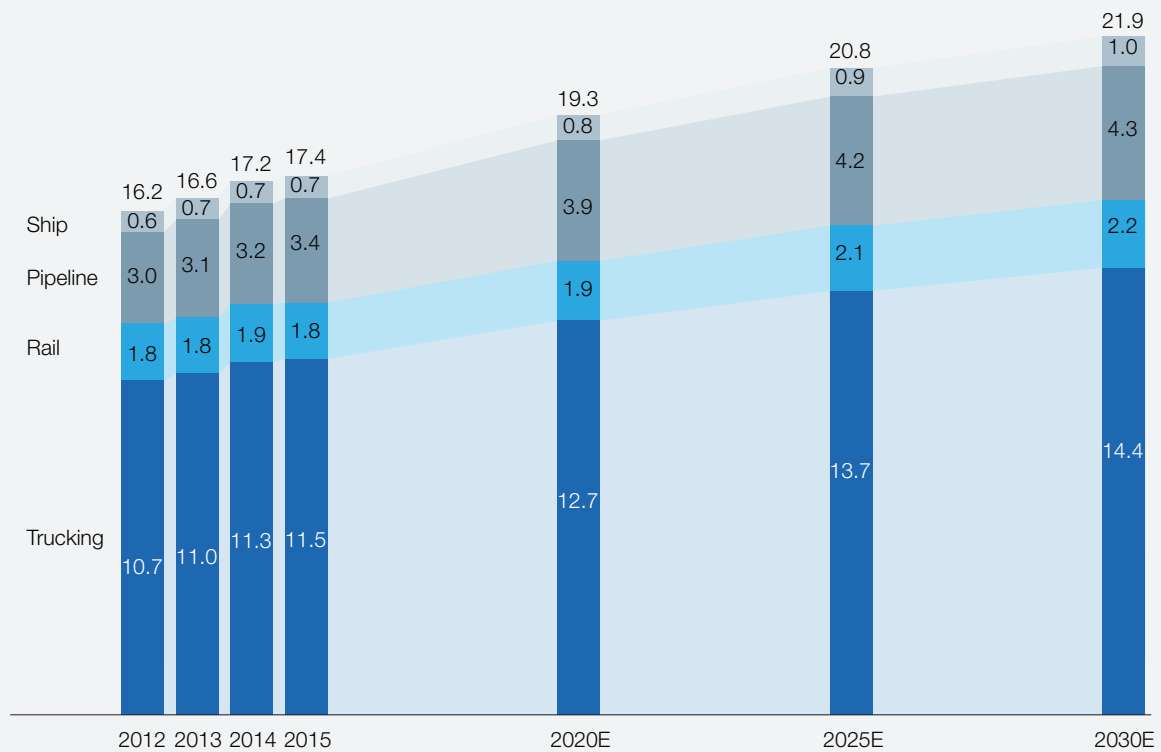
The biggest chunk of that savings will be on labor, as spend will fall to \$61 billion from the current \$85 billion. But that doesn't necessarily mean bad news for today's drivers. Autonomy will first take root on long-haul trips, which are the least popular among commercial drivers today. The industry's driver shortage is concentrated in these routes. Thus,

many of the jobs that will be filled by ATs are, in fact, currently unoccupied. We anticipate an increase in technical jobs to service and maintain the IT infrastructure that ATs need. We also anticipate job growth because of the need for local drivers to navigate ATs from the highways to their destinations and back.

Against those operating-cost savings, however, companies must absorb the higher capital cost of ATs. As Exhibit 2 shows, the industry's fastest-

### Exhibit 3 Trucking is the dominant mode of US inland freight transport.

US domestic shipping by means of transportation,<sup>1</sup> billions of tons



Note: Figures may not sum, because of rounding.

<sup>1</sup> Excludes multiple modes, mail, and unknown modes of transportation. Air freight accounts for a tiny portion of domestic shipping annually.

Source: Freight Analysis Framework version 4 by Bureau of Transportation Statistics and Federal Highway Administration

growing cost in recent years has been the fleet. Purchasing or leasing new power units has grown about 10 percent per year since 2012. That will only accelerate as ATs take to the highway.

The higher cost of ATs also introduces uncertainty about the value of aging vehicles and depreciation of new ones. We do not anticipate an impact on prices of used nonautonomous vehicles over the next five to ten years. AT substitution will come slowly, and, in the meantime, demand for nonautonomous vehicles will continue. A large fleet of conventional trucks will still be needed, and it will be quite a long time before autonomous vehicles enter the secondary

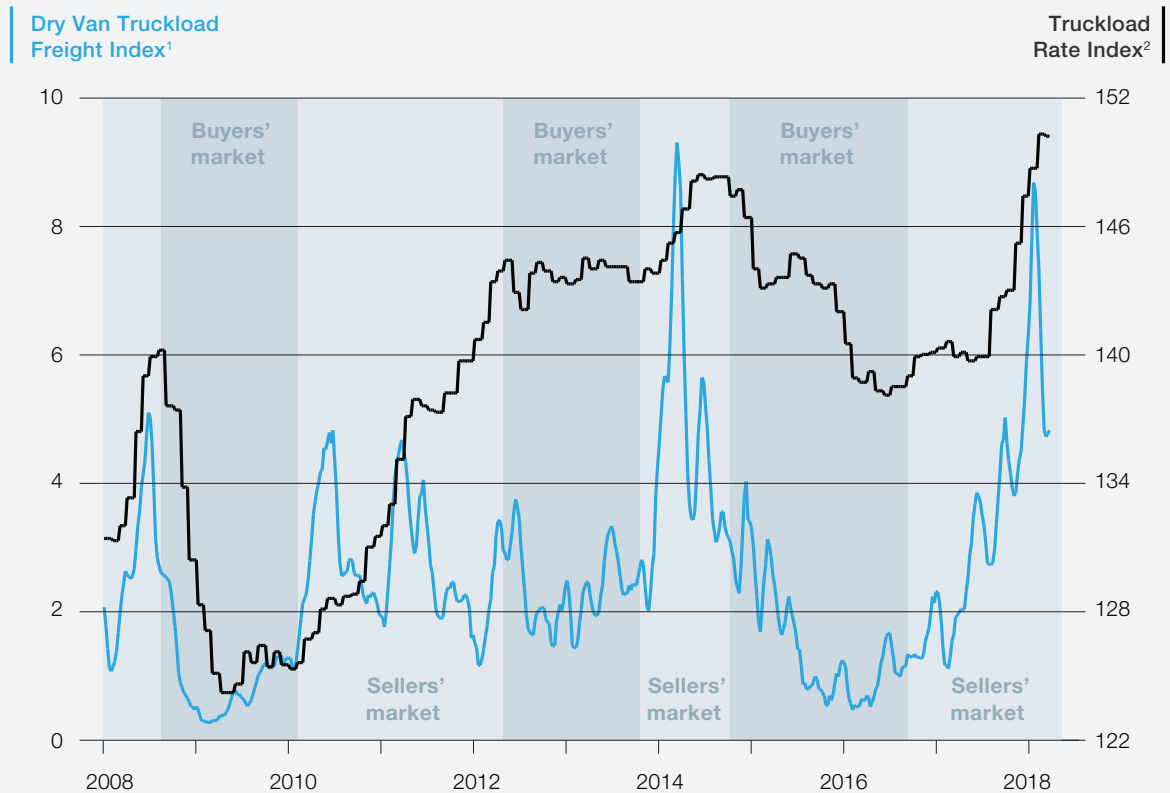
market. However, those investing in new technology will bear a risk of uncertain residual values. This risk, combined with more complex maintenance and open questions regarding liability, might accelerate the industry-wide trend to outsource fleet management.

#### Increased utilization of latent capacity

ATs are not subject to hours-of-service regulations, which limit the time a driver spends behind the wheel. By increasing driving hours from 11 hours per day to 20, ATs will be able to move freight faster and more flexibly, which will also allow shippers' supply chains to run faster. This increase in productivity could play out in a couple of ways. If demand grows, the national

**Exhibit 4 Trucking, a cyclical industry, has recently tightened.**

**US truck demand and for-hire rate**



<sup>1</sup> Index measures the available capacity of dry van trucks. Higher readings indicate demand for trucks is higher than available capacity.

<sup>2</sup> Rate based on Producer Price Index data for long-distance truckload. Latest 4 months are preliminary.

Source: JOC.com; *Logistically Speaking* blog, Transplace, [logisticallyspeaking.transplace.com](http://logisticallyspeaking.transplace.com); US Bureau of Labor Statistics

fleet could accommodate it without growing and so remain about the same size. If demand does not grow, the fleet might shrink. Our analysis suggests that in some likely scenarios, even as total miles driven increase, the fleet might shrink by 20 percent, though annual sales are likely to remain steady as highly utilized vehicles are replaced more frequently.

**Greater industry concentration**

ATs might cause a greater share of the market (particularly the long-haul portion) to consolidate

in the hands of the big trucking companies at the expense of owner-operator companies and other small companies. Three different kinds of scale economy will favor larger companies.

First, ATs can run longer, make faster trips, and eliminate the need for rest periods. Those benefits will save costs, as described. But they will also impose a new need for an infrastructure to troubleshoot and attend to some of the problems that drivers currently handle. Companies will need

a network of garages and shops to maintain vehicles and perform simple roadside maintenance. The largest companies are in a better position to build such networks.

Second, ATs are better able to take advantage of optimized routing software, which can identify backhaul opportunities and create preferential platoons. Autonomous technology uses constant connectivity to receive and transmit updates, creating a very high volume of data. Individual owner-operators are not as well equipped as large fleets to maintain, route, or manage this torrent of data.

Finally, larger companies will create more efficient platoons. And as things stand now, only the largest companies can organize the teams of local drivers needed when platoons leave the highway.

These factors suggest that the current full-truckload industry structure, in which about 90 percent of all carriers have fewer than ten tractors, will come under pressure. ATs and their technologies will be most easily deployed and exploited by larger carriers, which might claim a larger share of the industry as a result.

#### OEMs could expand vertically

Vehicle manufacturers see the potential for growth in transport as a service, which represents a new kind of revenue stream beyond or instead of the traditional sale. Already, General Motors is operating a small fleet of autonomous Chevy Bolts in San Francisco.

Transport as a service will become increasingly important as the value of vehicles shifts from their hardware to their software—and especially if that software is not written by OEMs.<sup>4</sup> Additionally, in an autonomous world, if OEMs retain the liability for the vehicles they produce, they are further incentivized to control the maintenance and usage

of their trucks. Although this shift requires changes to their balance sheets and the development of new business models, truck OEMs might easily pursue small pilot programs before digesting what they learn and expanding their operations. Many digital innovations start in consumer businesses, then transfer to B2B; we think transportation as a service might do the same.

#### Getting out in front of ATs: not as dangerous as it sounds

The forces unleashed by ATs have the potential to change the ecosystem dramatically. Industry consolidation would transform a fragmented industry that struggles to attract sufficient drivers into a digitally enabled short list of providers. OEMs and new entrants might compete for transportation-as-a-service share. And companies might tap their latent capacity through near-24-hour operations.

In the long term, each company should review these changes to the ecosystem and determine where it wants to play—and what it will take to win. This will require an understanding of the technological developments as well as the customer and competitor landscapes.

In the short term, each company can monitor the pace of change more closely through active participation. Autonomous-technology pilots allow companies across the supply chain—carrier, warehouse, railroad, and port—to test current technologies, learn from them, and prepare for future technology changes. Sitting on the sideline could mean watching autonomous technology, and the new value pools it creates, pass by.



For carriers (indeed, for most logistics subsectors), ATs are likely to bring disruption to operating models, cost structures, and economic models. And ATs are only one of five (or more) significant

**disruptions on the horizon. In this series of articles, we hope to offer companies in every subsector ideas on the roadblocks to avoid—and the straightaways where they can accelerate. ■**

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<sup>1</sup>“Route 2030: The fast track to the future of the commercial vehicle industry,” McKinsey Center for Future Mobility, September 2018, McKinsey.com.

<sup>2</sup> The range of years assigned to each wave reflects a conservative and an optimistic case for these factors, with many potential outcomes in between. Looking at other technology adoptions (such as for seat belts and ABS) tells us it can take decades to phase out old technology completely.

<sup>3</sup> Class 8, with a gross vehicle-weight rating of more than 33,000 pounds.

<sup>4</sup> Ondrej Burkacky, Johannes Deichmann, Georg Doll, and Christian Knochenhauer, “Rethinking car software and electronics architecture,” February 2018, McKinsey.com.

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