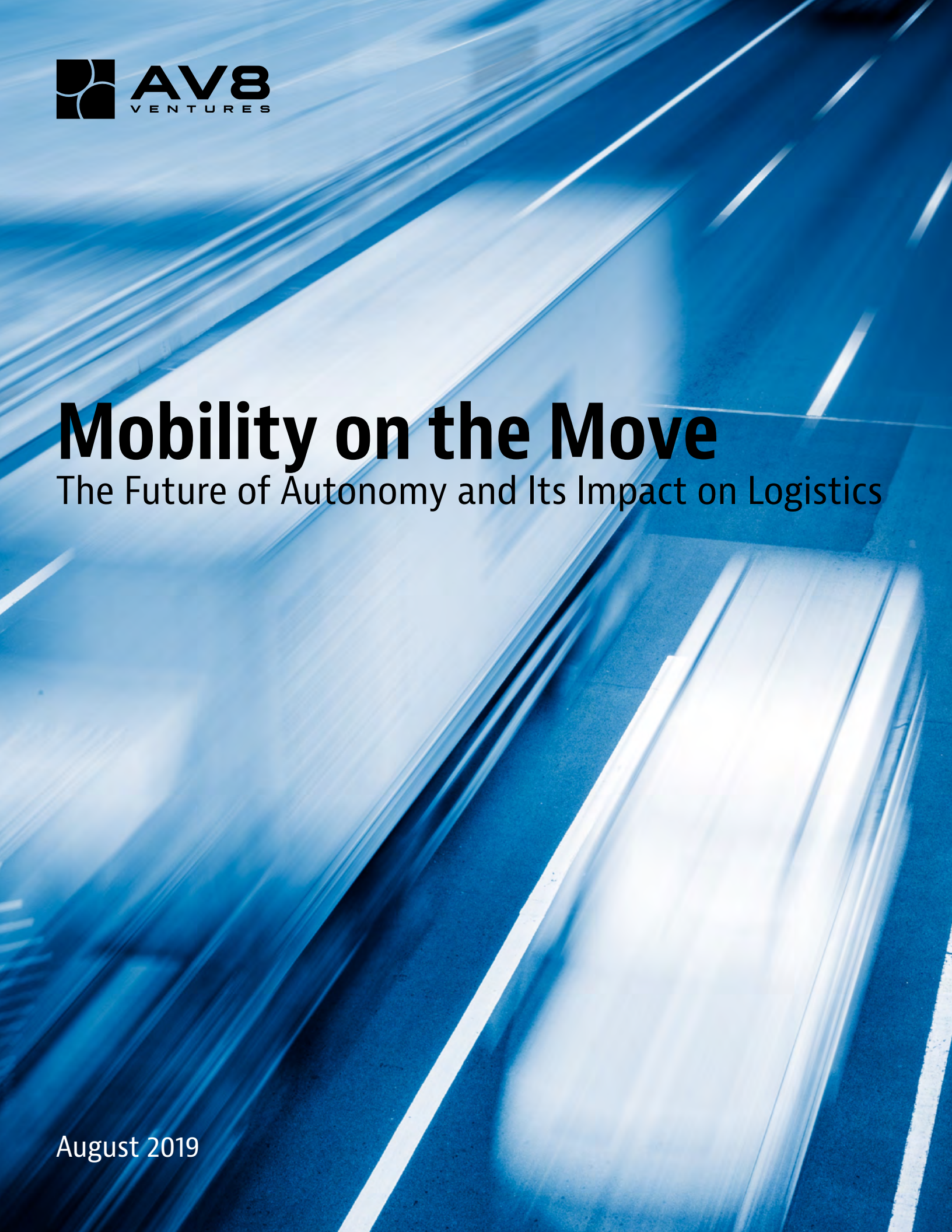

Mobility on the Move

The Future of Autonomy and Its Impact on Logistics

August 2019

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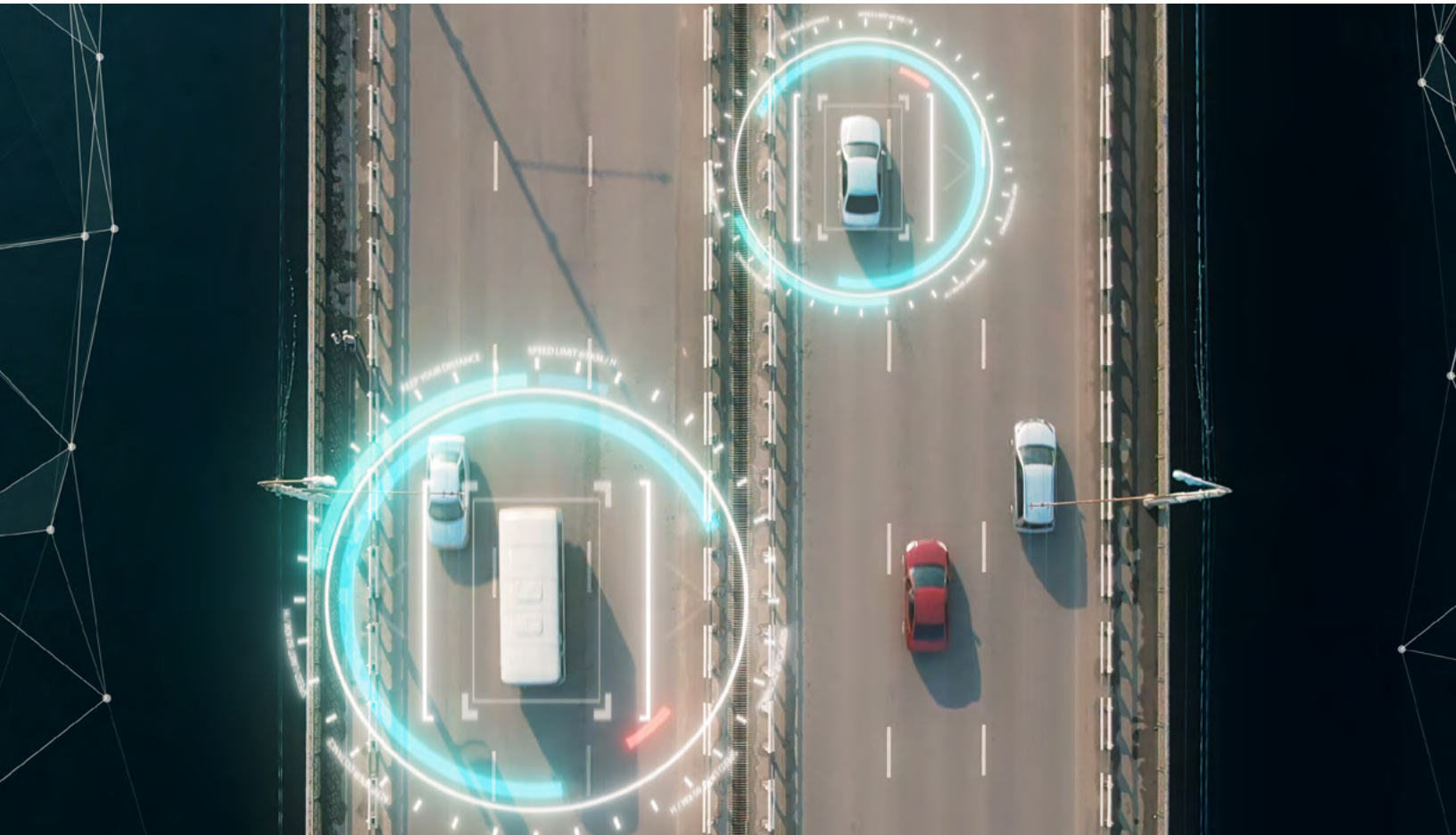
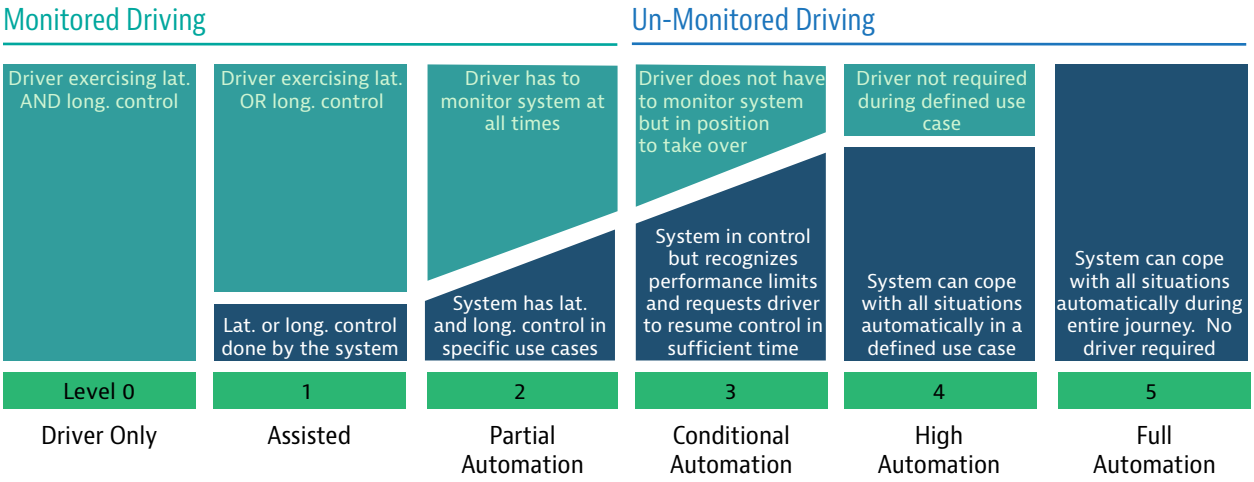


Introduction

Much has been written about the promise of autonomy and how it might revolutionize many aspects of our daily lives. However, as with many promising new technologies there can often be more hype and conjecture than there is clear-eyed assessment. Clearly, full SAE Level 5 autonomy (see below) is a massive, global opportunity that will impact almost every commercial endeavor. It can revolutionize how we transport ourselves and our goods. It can deliver $ Trillions in impact globally. In the US alone, the public benefits of full autonomy might reach $800 Billion by 2030 according to some estimates.

Levels of Autonomy (SAE)



Source: ZF-TRW, 2017

At AV8 Ventures, we have a front-row seat and access to key innovators and industry experts in the mobility sector. We don't believe full Level 5 autonomy will materialize for at least 10-15 years given the state of the technology, safety concerns, missing regulatory frameworks and the public's general unease with driverless vehicles. Even broad commercial deployment of Level 4 passenger car autonomy is many years away.

Achieving full autonomy is an incredibly hard problem to solve. We have seen companies quickly develop 80-90% of the technical elements of a self-driving vehicle in a straightforward way, only to realize that the remaining 10-20% is the hardest part and can take many years to complete as they essentially need to "build a driver" who can safely handle all the operating environments and edge cases. It requires an extraordinary amount of time and a massive amount of training data just to train the models required.

However, we see important high impact opportunities and applications that will emerge much sooner - within 2 years - in specific controlled, closed or geo-fenced environments:

- Closed environments like campuses, intermodal port facilities,warehouses and other private property use cases (i.e., people-moving shuttles in closed environments)
- Partial autonomy on open roads - specifically highway applications in the logistics industry

In this report we'll focus on the latter - breakthrough opportunities for autonomy in the global logistics and transportation industry principally those which can be brought to market in the next few years. The report also explores some key implications, opportunities and challenges that will emerge.

Logistics and Transportation - A Massive Opportunity

The global transportation and logistics industry is massive in size - nearly $6 Trillion worldwide today - and more than $1 Billion in the US. Trucking and the over-the-road transportation sectors are a major portion of this. These modes of transport touch almost every physical good consumed in the world and move more than 70% of all freight globally.

However, it's an industry under siege, buffeted by global forces:

Worldwide shortage of drivers (and getting worse)

The US is currently short 60,000 drivers growing to 100,000 in the coming years. It's ten times that worldwide.

Accelerating growth of e-commerce

The "Amazon Effect" has created almost unrealistic expectations for any product delivered from/to anywhere within 24 hours. This is a massive shock to existing transportation and logistics networks.

Low asset utilization and razor-thin operating margins

For logistics carriers, each $1 of Revenue generates only ¢4.8 in Profit. This comes with significant on-ongoing CapX needs for heavy equipment (trucks are typically replaced every 5 years).

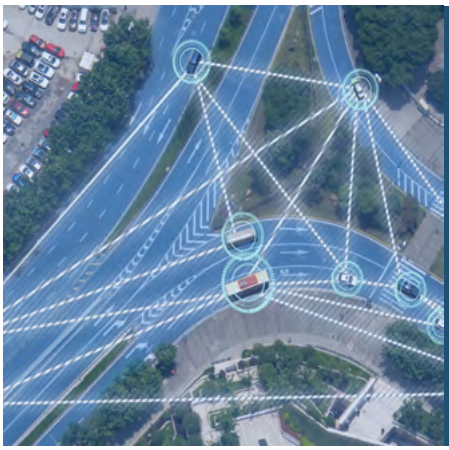
Highly fragmented and inefficient industry

In the US there are 770,000 for-hire transport operators, 90% of which operate fewer than 6 trucks (many of these are independent owner-operators who contract out to the major carriers).

Unfortunately, the logistics sector's historical adoption of technology has lagged the automotive sector. We see this starting to change with:

- OEMs adding more Level 2 driver-assist technologies to vehicles
- More adoption of digital tools (i.e, TMS software, digital load boards)
- More innovators targeting this sector given its size, importance and challenges

The historical lack of innovation and adoption underpins some of the industry's critical challenges.

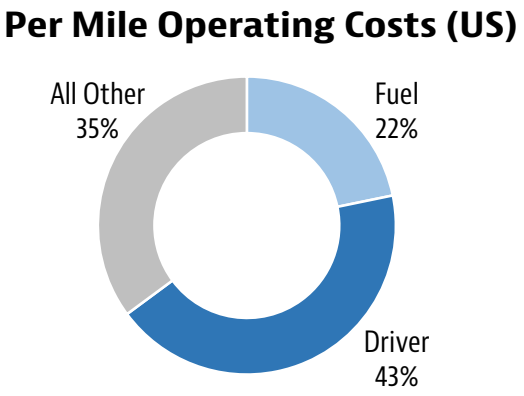


"Our goal is not to build a car, we are really building a driver"
Dmitri Dolgov
Waymo CTO

Autonomy's Impact on Logistics

In the face of these challenges, autonomy will have a massive role in not only saving an industry at risk but unlocking its ability to meet future consumer expectations that have dramatically changed due to companies like Amazon.

Nearly ½ of the total operating cost of truck shipments are driver expenses. As well, more and more countries are imposing hours of service constraints that significantly challenge long-haul logistics. In the US, drivers can only work for 11 hours straight (with a 30 minute break) before having 10 consecutive hours of downtime. This further challenges an already challenged industry. Fortunately, autonomy provides disruptive means to overcome these obstacles thereby saving $ Billions for carriers, shippers and consumers.



With full autonomy reducing most of the driver expense and a portion of the fuel costs, we estimate total operating costs could decrease by as much as 45-50%. What does that mean for the trucking industry: a 45% cost reduction on a 5% margin, $6 Trillion global business drops $2.3 Trillion to the bottom line.

"In the medium term (through 2040), on-highway trucks will likely be the first vehicles to feature the full technology on public roads."
McKinsey and Co.

Autonomous Logistics - Example Approaches

There are many considerations that go into designing and deploying an autonomous logistics solution. First and foremost is the technology and its ability to safely operate in any regime. Beyond the technology, other important considerations in developing autonomous platforms include:

- the freight load (including nature of load, load requirements, origin/destination)
- operational assets utilized/required
- mode of transportation
- government regulations

Understanding each component and how they interact allows optimization for each mode of transportation. In other words, there are several ways one can go about bringing autonomous solutions to market for logistics, based on these criteria and the intended use cases.

Example Use Case - Private Property or Protected Environments

Taking the above into consideration, an example where autonomy will come to this sector sooner rather than later is in controlled environments like warehouses, factory yards and port container transfer facilities. These environments are much simpler use cases with discrete operating lanes, fewer pedestrians to worry about, and often routine freight moves (i.e., move a shipping container from a known and fixed position A to a known and fixed position B). Several companies are developing these solutions and we expect them to be widely available within the next 2-3 years.

Einride - A Swedish transportation company developing medium-duty cargo moving autonomous vehicles. Their goal is full autonomy in controlled environments - an interesting albeit niche market. They are developing a truly driverless medium duty electric transport vehicle called a T-Pod. The T-Pods carry about ½ the weight of a fully loaded commercial truck (26 tons vs. 40 tons). Their initial focus is moving loads between a warehouse and a terminal, and within the confines of an industrial plant - typical geo-fenced use cases.

Nuro - A California based start-up focusing on last-mile delivery, who has raised $1 Billion in funding primarily from SoftBank. While their technology can be used for other applications (see below), Nuro is focused on light-duty local delivery with initial partners in the food and grocery sector. They have built a driverless, all-electric local delivery vehicle. They are targeting a few narrow but still challenging operating regimes (including neighborhood and campus level food delivery). Their current pilots involve a chase car driving behind it in which a human can remotely take over and operate as needed. We believe it will be some time before a platform like this is commercially deployed on open roads but could see limited use sooner in more protected or closed scenarios.

Example Use Case - Heavy Duty Commercial Trucks

Given the size of the global freight opportunity, we see a significant amount of investment going into either retrofitting existing heavy duty trucks or creating new ones altogether. Rapid advances in sensors, AI and computing platforms have made this possible. Much as Waymo has found after testing autonomous passenger vehicles for more than 7 years, these firms are realizing that the 1st 80% is easy but the complete Level 5 solution may easily be 10-15 years away even for long haul highway use cases that in some ways are simpler than passenger cars on urban/suburban roads. Therefore they are adopting their approaches accordingly.

Start Ups Retrofitting Existing Trucks

Starsky Robotics - a California start-up that is retrofitting existing vehicles for the freight market. They are initially targeting a Level 4 approach whereby a remote human operator is overseeing the vehicle operation - similar to the way in which military drones are remotely piloted. This helps overcome the first mile/last mile challenge in freight (i.e., navigating off-highway around local streets where pick-ups and drop-offs routinely occur). However, even in highway operating regimes - where someone takes over upon highway exit - a fully unsupervised vehicle operating autonomously will take years to be practical. There are also numerous challenges with a remote operator safely handling first mile/last mile duties. They will initially go to market with freight hauling services using their trucks and their drivers - including an on-board safety driver.

Embark Trucks - a California start-up similar to Starsky Robotics. Embark is taking a similar approach in retrofitting existing commercial trucks. However, instead of a remote pilot they initially have a safety operator riding in the vehicle at all times. While this is safer than a remote operator, it unfortunately mitigates the major cost savings by requiring someone to travel with the vehicle wherever it goes.

Ike Robotics - another well funded California start up similar to Embark and Starsky. They intend for their trucks initially to operate autonomously only on highways, with human drivers taking control for first mile/last mile. Unlike the others above, however, Ike is licensing key pieces of its vehicle software technology from Nuro.

Others - including OEMs, Waymo and Uber.

Numerous vehicle OEMs from Tesla to Volvo to Daimler have committed substantial resources to deploying an autonomous truck - electric or otherwise. While we are encouraged by these projects (Daimler has committed $570 Million to the effort in the coming years; Tesla's semi has logged many coast-to-coast miles in the US), as described above true Level 5 autonomy will be a long time coming and we anticipate those serious about these projects to field Level 2/3 solutions in the interim which will still be important for the industry.

Among traditional OEMs, Daimler is the farthest along. It announced its Inspiration Truck in 2015 as a concept vehicle. It is now bringing elements of this solution i.e., models with adaptive technologies and other ADAS capabilities to the market with a Level 2 enabled model launched in 2019.

Google/Waymo has demonstrated their autonomous capabilities in a truck format but remain focused on a) the underlying technology and b) how it might be used for passenger vehicles. We do not anticipate Waymo focusing on the logistics sector unless they become pressed to show any sort of near-term commercial

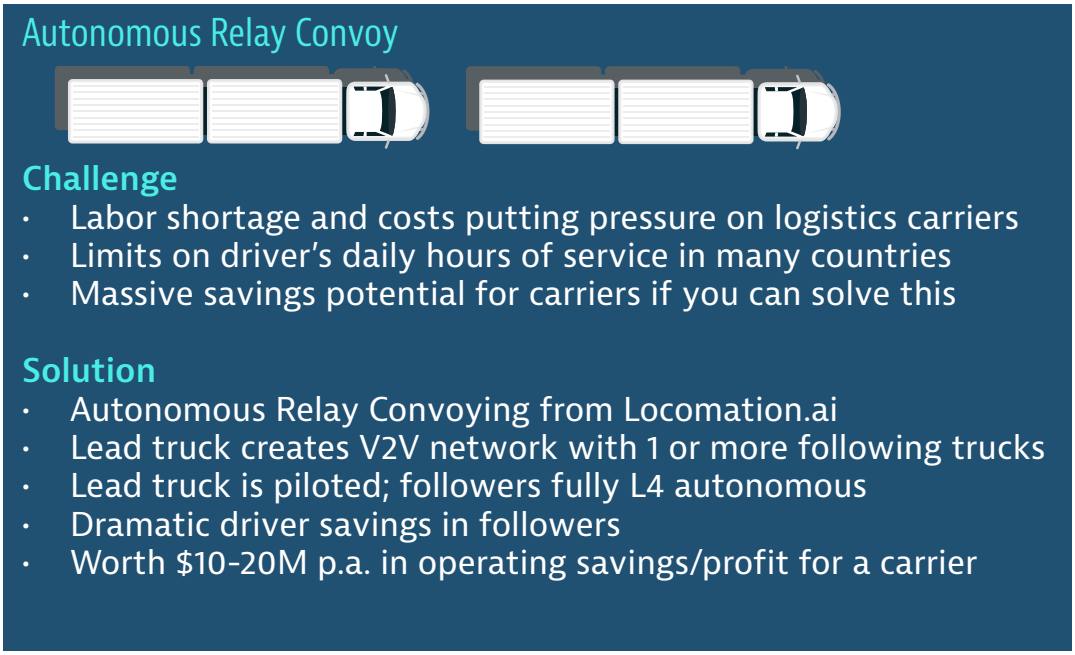
deployment, that's not simply a proof of concept or limited test.

Uber invested heavily in autonomous trucking including acquiring Otto for $680 Million in 2016. That deal unraveled for multiple reasons including lawsuits with Google/Waymo over the founder and stolen IP, mass team exoduses and shifting priorities at Uber. They have now ceased efforts in logistics and are focused only on automobiles.

Example Use Case - Level 4 Autonomous Relay Convoying

Autonomous Relay Convoying (ARC) is a promising approach to near-term deployment of Level 4 autonomous trucking. Our investment in Locomation.ai exemplifies this approach whereby 2 or more trucks are deployed in a vehicle convoy via retrofitting existing trucks. The trucks have Level 4 autonomy and are linked together in a vehicle to vehicle network. However, unlike other approaches the lead truck is piloted while the following truck autonomously follows the leader at a close distance. In this way, the piloted vehicle is navigating and handling corner cases as they arise as well as taking the lead on first mile/last mile. The following vehicle simply follows what the lead truck does and is fully automated without the need for a driver.

The operational savings for carriers is impressive: up to 50% labor savings (i.e., 2 trucks, 1 driver); up to 10% fuel savings. ARC has regulatory approval or pending approval in 25 states in the US and parts of Europe and Asia, and will be commercially available in 2021. ARC-enabled fleets will generate millions of real world miles in the coming years (and generating significant revenue for Locomation.ai) which will help them develop their own fully autonomous Level 5 solution in the future, whereby single trucks will ultimately operate independently and autonomously.

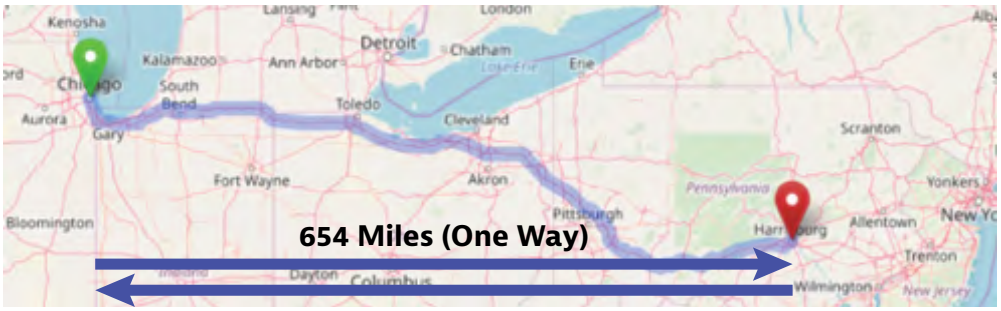


ARC Deployment Example

Consider the US route between Chicago, IL and Harrisburg, PA. This route is popular as Chicago is a major logistics hub and gateway to much of the Midwest, and from Harrisburg LTL/local carriers can easily reach major population centers like New York, Philadelphia and Washington DC.

To cover this distance (654 miles one way) a traditional carrier would either have to change drivers halfway in Cleveland, OH or use a team-driving model employing 2 drivers who have to take turns. Below are the operating economics of this route before ARC and after ARC, showing significant cost savings and profit improvement.

ARC Network Map



Operating Economics (per Truck)	Lane Distance: 654 Mi.	
	Before ARC	After ARC
Revenue Expected (per Truck)	$2,047	$2,047
Total Operating Cost (per Truck)	$1,949	$1,672
Profit Margin	5%	14%

Major Implications for the Future

New Business Models Emerge

Full autonomy, whenever it comes, has the potential to unlock dramatic changes in business models for incumbents and new entrants. For example, in the automotive space OEMs including GM and Tesla have announced their intent to develop "mobility-as-a-service" offerings to take advantage of autonomous technology and to address changing customer demographics. Similar opportunities will exist in logistics.

Today, the logistics industry already has players who essentially run "logistics-as-a-service" operations. These include asset-free carriers who only use contract transport operators as well as 3PL firms. However, with the advent of autonomy, truck OEMs - both legacy and new entrants - are also evaluating new business models around mobility-as-a-service. These models have huge implications and challenges for OEMs requiring them to move from 1-time sale, product oriented, fixed supply chain businesses to an on-going customer engagement, global services oriented operation and more engagement with end shippers. Note that more and more value will be carried by the software and autonomous elements which may or may not be developed by the OEMs. OEMs who go down this path may end up competing with their existing customers, however. Hence, we believe it more likely new entrants will be first-movers toward transport-as-a-service rather than legacy OEMs. For instance, TuSimple - a China backed autonomous trucking company - is deploying this model today. They are contracting for demonstration-style freight hauls in the southwest US with shippers like the US Postal Service.

Additionally, autonomous vehicles are rolling data platforms that can provide massive amounts of telemetry on not only the position of the vehicle and its driving patterns, but also the surrounding environment (traffic, accidents, weather, etc). We anticipate new business models to form around leveraging this data once the industry's autonomous rolling stock reaches critical mass.

These data and the insights and predictive models derived from them will be particularly valuable to the shippers themselves and their supply chain partners especially as they move toward global just-in-time inventory and deliveries: imagine Walmart being able to predict with a much higher degree of accuracy and within a 1 hour lead time exactly when trucks in-bound for a store will arrive carrying items scheduled for delivery that day. This is a potential profitable new opportunity for carriers.

Insurance Will Dramatically Change

Who's Responsible?

We envision many changes for insurance in an autonomous future. Dramatically fewer accidents is an obvious change (see below). The migration from insuring humans when accidents occur to covering OEMs from liability of technical failures and bugs is another one. When Level 4/5 autonomy arrives, the liability will shift from Driver to Vehicle and possibly even to Manufacturer. As Volvo CEO Haken Sammuelsson famously said in 2015, "Volvo will accept full liability whenever one of its vehicles are in autonomous mode".

This leads to the unresolved question of who really was at fault in an accident: the driver, the OEM or the software programmer (who may be a supplier to the OEM). We anticipate this issue will take some time to resolve, with legal precedent being established on a case by case basis. Insurance companies have a unique role to play in helping define future coverage approaches for all parties who may face exposure.

Fewer accidents, with fewer bodily injuries and fatalities (see below), mean not only fewer claims but much lower loss costs by insurers. However, along with lower risk profiles comes the expectation of lower premiums paid by those insured. Some estimates predict up to 50% reduction in premiums are possible in the long-term when fully autonomous fleets are widespread.

"The bottom line for auto insurers is that the cost of doing business the same way they've traditionally done it, in terms of lost revenue and market share, will likely be far higher than the price of change. For an historically conservative industry such as insurance, this observation has possibly never been more appropriate.
As society increasingly embraces the future of mobility, and as expectations for ease, convenience, and cost effective products and services grow, insurers should position themselves to take the driver's seat, or all evidence suggests they could lose this race."
Deloitte

This represents both a threat and an opportunity for insurers. For instance, one could envision much higher profitability and markedly enhanced operating ratios in the future as they change their focus from drivers to vehicles and OEMs, albeit with fewer clients and reduced revenue from the sector. However, with fewer accidents, the insurance industry will see both fewer policies in force as well as reduced premiums given the safety potential of autonomous vehicles. This could favor diversified insurance portfolios which don't rely on the transportation/automotive sector for their primary book of business.

Self-Insurance

In the era of autonomy, will truck OEMs themselves become primary underwriters of their vehicles - especially if they also become mobility-as-a-service providers and the shipper of record? Tesla has already moved in this direction with automobiles. In 2017, they announced a policy in conjunction with Liberty Mutual as a first step, and have now expanded this effort announcing in May 2019 a new initiative targeting direct underwriting. For Tesla, this could be a disruptive offering given:

- the growing size of their fleet
- their deployment of AutoPilot and other ADAS technologies
- the potential liability faced by OEMs in an autonomous future
- the massive amount of driver data they possess
- the ability to model and price risk of each driver based on this data

For the logistics sector, it is unclear if existing OEMs are capable of a similar effort although today the largest ones have some measure of self-insurance. It would require a very strong balance sheet and a different

set of skills. If they offer mobility-as-a-service they would no doubt need to offer cargo insurance as well. The largest players including OEMs and their technology partners might chose to collaborate and pool risks together. And with higher capacity utilization of their fleets, there will be fewer vehicles to underwrite in the future. While a threat to direct insurance, this would open up opportunities for reinsurance.

Data-Driven Opportunities

Even if the OEMs don't offer this themselves, there is a unique opportunity for underwriters to take advantage of autonomy's technical attributes to rethink the types of offerings they provide to the vehicle OEMs and carriers. For example, leveraging the detailed telemetry to better assess and price risk or deploy usage-based products, will lead to more profitable opportunities for insurers to extend coverage to autonomous trucks. This will also take place sooner rather than later as Level 2/3 implementations will all start capturing sensor-based data and will be in-market shortly. This will require insurers to significantly re-architect their IT and business systems to capture, analyze and take advantage of massive amounts of telemetry data which they don't handle today. It will also require the OEMs' cooperation.

Cyber Threats

Insurers will also have new opportunities in underwriting cyber risks for OEMs. As autonomous vehicles become large mobile connected computing platforms they also create more attack surfaces for cyber criminals, especially vehicles carrying high-value or sensitive cargo. There have already been multiple demonstrations of security vulnerabilities and hacks to autonomous vehicles. For example:

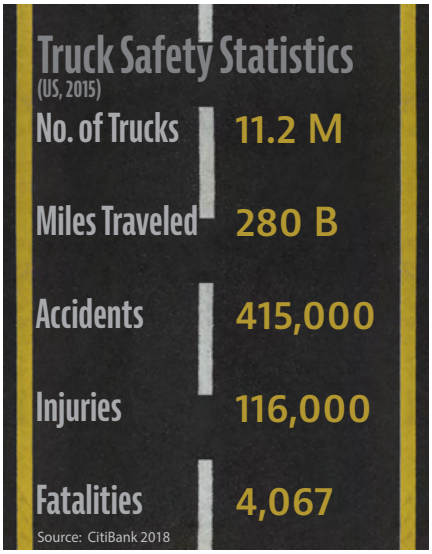
- In 2016 a Chinese Security Firm (Tencent Keen) remotely hacked a Tesla Model S from 12 miles away.
- In 2019, the same firm placed interference markers on a test road and successfully diverted a Model S away from its course, tricking it to change lanes.
- Security experts have routinely hacked into the key systems of multiple makes and models recently.

This creates a new line of business to provide OEMs in the future.

Reduced Accidents and Significant Life Savings

More than 1.25M people die each year globally from motor vehicle crashes of all types. An additional 20-50M people are injured or disabled annually from crashes. Trucking is a dangerous occupation: more truck drivers die each year than any other single occupation, making it one of the most dangerous jobs in the US.

Driver-related issues like inattention, drowsiness and poor decision-making account for nearly 90% of all large truck fatal or injury accidents. The frequency and severity of truck accidents will drop dramatically as autonomy penetrates the sector. This in turn will likely erase $ Billions in claims damage globally, save tens of thousands of lives and prevent millions of injuries. Even with near term implementations of Level 2/3 capabilities in trucks, we expect to see measurable reductions in accidents, deaths and injuries.



Conclusion

Bright Future for Autonomy

A significant amount of investment has been made in autonomous vehicles. These technologies have the potential to dramatically impact an industry in crisis - the $6 Trillion global logistics and transportation industry. While deploying autonomous vehicles to highway driving is an easier problem than passenger car use cases, the problems associated with full mobility in the trucking sector are still quite daunting. We believe that full autonomy in this sector won't arrive for at least 10 years. But we also believe that there are opportunities to generate significant value for transportation carriers in the near term, with approaches like ARC. Further, a step-wise drive toward full autonomy is vital given the amount of real-world training data required to fully develop Level 5 solutions, and its cost.

Challenges and Opportunities for Insurers

As with any disruptive technology, autonomy in the logistics sector will bring both challenges and opportunities for insurers.

- Perilous truck accidents will be dramatically reduced - but so will premiums, policies in force and loss costs
- When an accident occurs, who is ultimately responsible - the driver, the OEM or the software programmer - will need to be sorted out. However, insurers have an important role to play in setting the context and agenda for these deliberations.
- New data-driven models will emerge for underwriters but will require changes and new thinking for them to take advantage
- Cyber risks can't be taken lightly especially with high-value and sensitive cargo being transported

It is said that the future belongs to those who prepare for it. The next generation of industry leaders that we see are the ones preparing to capitalize on these changes today.

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