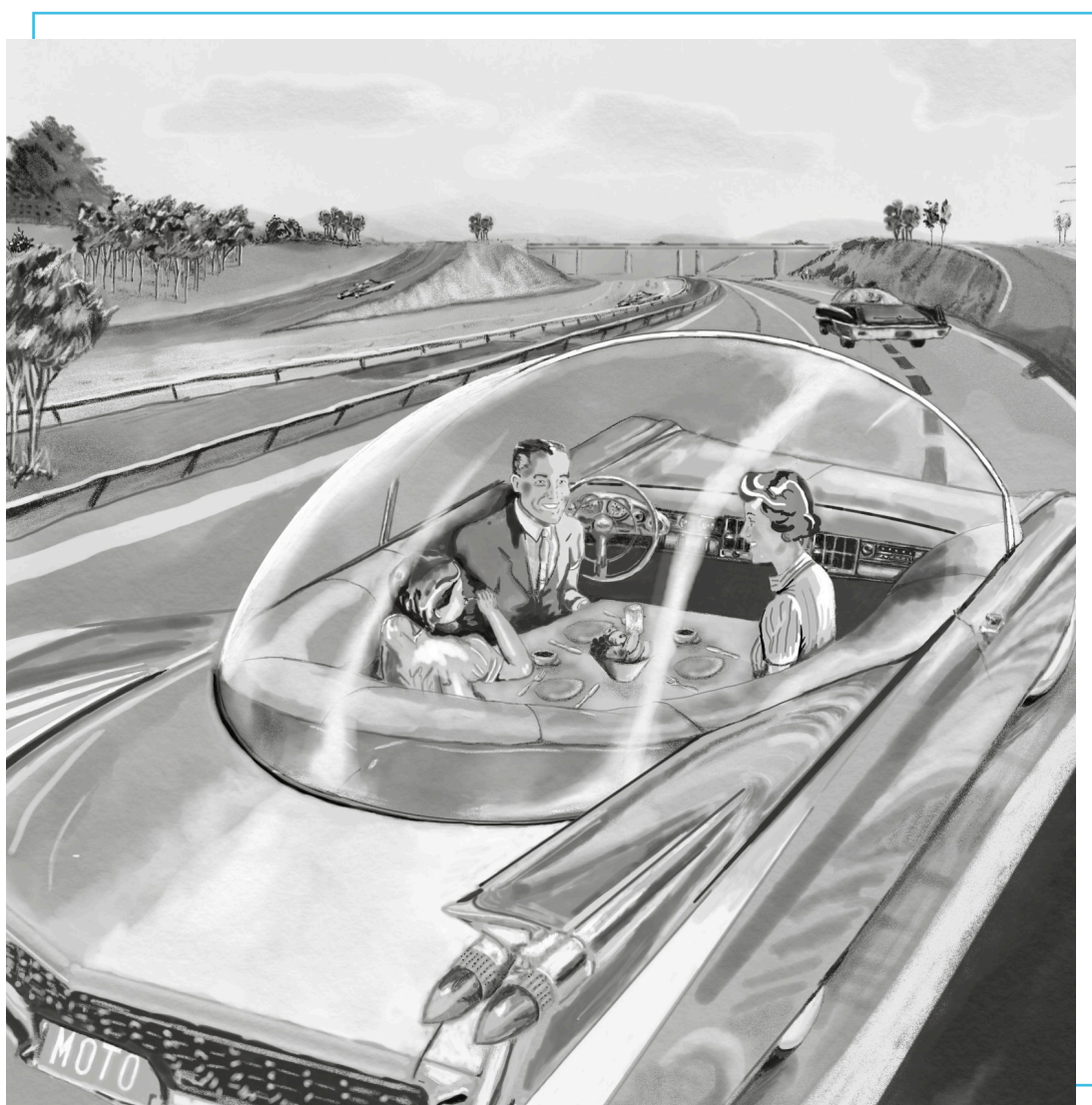




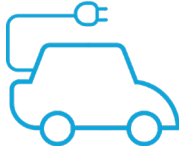
SmartETFs

# The Smart Transportation Revolution



What is

# SMART TRANSPORTATION?



Electric Vehicles

Autonomous Vehicles



App-Based Ridehailing

Flying Taxis



Connected Vehicles

Drones



Better Public Transit

& more

# A Vision of the Future

Buckle up. Your flying taxi is about to take off.

A revolution may be upon us; a revolution that may transform the human experience and reshape cities across the globe. The early stages of the revolution may not look like much. But, if the future of transportation is even partially as it might be then we are about to experience profound changes in the way we live. The transportation revolution could mean:

- Electric Vehicles replace gasoline powered vehicles.
- Self-driving cars become a reality.
- Autonomous flying taxis begin serving customers.<sup>1</sup>
- Autonomous transportation as a service could mean many, if not most, will not own their vehicles.

In this report we lay out predictions and the implications for a smart transportation revolution.

## What is Smart Transportation?

What do we mean by smart transportation? We mean a number of things, all of which represent considerable improvements over today's transportation. Smart transportation is autonomous vehicles. It is electric vehicles. It is vehicles seeing and communicating with each other. It is ride sharing and transportation as a service which will result in considerable savings for consumers. It is the efficient use of vehicles rather than having them be parked 95% of the time. It is the autonomous delivery of goods. It is autonomous flying taxis. It is better and cheaper public transit. It is hyperloop and other forms of faster, more efficient ground transportation. It is less time in traffic. It is more inclusive. It is many thousands of lives saved. It is less pollution. It's just, well, smart.

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<sup>1</sup> As we discuss later, several firms are stating they will have this service in place by 2023. Trial services are set to start in 2020.

Imagine a life where you spend time in transit productively, working or enjoying time with friends and family. Imagine a future where homes no longer need large garages and cities no longer need massive amounts of parking.

This future is brought about by the convergence of three elements: electric vehicles (EVs), autonomous vehicles (AVs) and application-based transportation as a service. This convergence could mean the average US household saves several hundred dollars per month on transportation costs.<sup>2</sup> Here are the steps required to achieve this vision of the future.

**Step 1** Electric vehicles become more affordable than Internal Combustion Engine (ICE) vehicles.

**Step 2** Autonomous vehicle technology continues to improve to the point where driverless vehicles are deployed.

Once these steps are achieved consumers will have a compelling new option for daily transportation.

### Step One: Can Electric Vehicles (EVs) become more affordable than Internal Combustion Engine (ICE) vehicles?

Step one requires continuing declines in the battery prices. The battery is the most expensive single component in an EV. Currently estimated to be \$200 per kWh,<sup>3</sup> the battery cost means an EV is more expensive on an upfront basis than a comparable ICE vehicle. Battery costs have been on a long-term price decline: Bloomberg New Energy Finance calculates that EV battery costs have declined 85% since 2010 including an 18% decline in 2018.<sup>4</sup> The question is: At what price is the EV battery cost low enough to compete head to head with the cost of a comparable ICE vehicle? Some believe this price is \$125 to \$150 per kWh. We've seen other estimates at \$50 per kWh. There may not be a single magical price point; different consumers will react to the cost/utility tradeoff differently. Arguably, EVs are already cheaper than ICE vehicles in some regards. Fuel costs alone are about 75%<sup>5</sup> cheaper for EVs over ICE vehicles; an annual savings of

<sup>2</sup> There are numerous estimates from various sources regarding the cost advantage to autonomous vehicle-based transportation as a service. We are estimating an average savings of \$500 per month per household, and is based on an Esurance estimate of a savings of \$0.23 per mile savings and a 13,000 mile per year per vehicle estimate. This is a savings of \$2,990 per vehicle per year and the average number of vehicles per household is two. RethinkX believes the savings will be \$5,600 per year per family "...potentially generating the largest infusion of consumer spending in history." (Rethinking Transportation 2020-2030). Esurance source can be found here: <https://www.esurance.com/insights/self-driving-cars-save-money>

<sup>3</sup> Source: Union of Concerned Scientists <https://www.ucsusa.org/clean-vehicles/electric-vehicles/electric-cars-battery-life-materials-cost#bf-toc-2>

<sup>4</sup> Source: <https://www.bloomberg.com/news/videos/2018-12-21/bnef-brief-lithium-battery-prices-fall-18-percent-video>. See also <https://thinkprogress.org/electric-vehicles-gas-cars-cost-31a68bcdcee1/>.

<sup>5</sup> Source: [https://www.2degreesinstitute.org/reports/comparing\\_fuel\\_and\\_maintenance\\_costs\\_of\\_electric\\_and\\_gas\\_powered\\_vehicles\\_in\\_canada.pdf](https://www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf)



\$1,000 assuming 10,000 miles. Maintenance costs are also cheaper for EVs<sup>6</sup>; they contain significantly fewer moving parts and require significantly less maintenance.<sup>7</sup> Generally, if battery costs were to decline to \$50 or less per kWh then there is little doubt that EVs will represent a better cost/utility option than an ICE vehicle. Bloomberg New Energy Finance is estimating that the upfront cost of an EV will be cheaper than comparable ICE vehicles by the early to mid-2020s.<sup>8</sup>

While the upfront cost of an EV is higher than comparable ICE vehicles, the total cost of ownership, which includes fuel and maintenance, are significantly lower for EVs. Many individual consumers are not willing to pay more up front even if the lifetime costs are cheaper. However, the cost equation is entirely different for fleet operators, including Waymo, Uber and others who will be expecting vehicles to last 500 thousand miles or more.<sup>9</sup> Operators expecting their vehicles to deliver that many miles will logically pay a higher upfront cost if their lifetime operating costs are significantly lower.

## Step Two: Autonomous Vehicle Advancements

Step two requires that vehicles become

self-driving. This will require that current autonomous driving technology improves from the current state of the art. The following page on the Levels of Autonomy describes the various levels of automotive autonomy. We recognize that the technology required to move from one level to the next is exponentially more difficult to achieve. Thus it is a much easier challenge to implement cruise control than it is to “teach” a car to change lanes automatically. It is significantly harder to “teach” the car to choose a lane, decide when to exit the freeway and then navigate through the hazards and challenges of neighborhood traffic. Fortunately, the computing power and data collection are also growing exponentially. The challenge is sufficiently complex to make it very difficult to predict when full autonomy will be achieved.

It is worth highlighting two different companies that are taking two distinctly different approaches to solving the autonomous vehicle challenge: Waymo and Tesla.

### Waymo

Waymo, which is Alphabet’s (Google) autonomous driving initiative, has been driving a fleet of test vehicles in a number of locations gathering data, learning and *(continued on page 8)*

<sup>6</sup> NYC reported a dramatic reduction in maintenance costs for their all electric fleet vs. their gasoline powered fleet citing a minimum reduction of 75%. See: <https://electrek.co/2019/03/18/nyc-maintenance-electric-cars/>.

<sup>7</sup> There are a large number of parts required by IC engines that are not required by EVs including spark plugs, carburetor, catalytic converters, valves, camshaft, pistons, connecting rods and timing belts just to name a few.

<sup>8</sup> Source: <https://www.bloomberg.com/news/videos/2018-12-21/bnef-brief-lithium-battery-prices-fall-18-percent-video>.

<sup>9</sup> While it is possible to expect an ICE vehicle to provide one-half million miles or more, it is far more likely that an EV will be able to efficiently deliver such a range over its lifetime. This has everything to do with the complexity and number of parts and wear for an internal combustion engine vs the simplicity of operation of an electric motor.



# LEVELS OF AUTONOMY

Professor Alain Kornhauser of Princeton University has articulated three levels of vehicle autonomy which we believe go a long way to understanding the path to implementation better than the more widely circulated six levels of autonomy. Professor Kornhauser's three levels of autonomy: safe-driving cars; self-driving cars; and, driverless cars. Here is how he defines the three levels:

**Safe-driving cars** use sensors and intelligence to keep cars from crashing. This would include automatic breaking and lane control. These technologies are in use today.

**Self-driving cars** are vehicles that can drive themselves but not well enough to do it without a driver. This level of technology has been achieved by a number of companies primarily those operating ride sharing services. Tesla is offering this capability to consumers now.

**Driverless cars** are vehicles that don't have, or need a driver. There are limited examples of this in the real world.

What is important about Kornhauser's three levels is that not only are they easier to understand but they make it easier to appreciate the progress made and still needed to be made. Where naysayers might say that Level Five autonomy is impossible it is clear that real progress has been made just in the added safety of safe-driving cars.



The National Highway Traffic Safety Administration (NHTSA) has adopted six levels of autonomous vehicles ranging from zero to five. The levels<sup>10</sup> are:

## Zero

No automation  
The human driver does all the driving.

## One

Driver assistance  
Vehicle is controlled by the driver, but some driving assist features may be included that can assist the human driver with either steering or braking/accelerating but not both simultaneously.

## Two

Partial Driving Automation  
Vehicle has combined automated functions, like speed control and steering simultaneously, but the driver must remain engaged with the driving task and monitor the environment at all times.

## Three

Conditional Driving Automation  
An automated driving system on the vehicle can itself perform all aspects of the driving task under some circumstances. A driver is still a necessity but is not required to monitor the environment when the vehicle is engaged. The driver is expected to be takeover-ready to take control of the vehicle at all times with notice.

## Four

High Driving Automation  
The vehicle can perform all driving functions under certain conditions. A user may have the option to control the vehicle.

## Five

Full Driving Automation  
The vehicle can perform all driving functions under all conditions. The human occupants never need to be involved in the driving task.

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<sup>10</sup> See: this document from the NHTSA from which we borrowed much of the language for these definitions. [https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13494\\_812555\\_l2l3automationhfguidance.pdf](https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13494_812555_l2l3automationhfguidance.pdf)





Image courtesy of Waymo

refining their capability. They have accumulated over 10 million miles of autonomous driving since 2015. Waymo is already offering autonomous app-based transportation to consumers in Phoenix, and in late October 2019, they began testing the service without a safety driver.<sup>11</sup> They are expected to begin offering this service without the safety driver in the near future. That they are on the cusp of driverless vehicles without reaching autonomy Level 5 is a function of the limited offering area. The levels of autonomy don't distinguish between various location and route challeng-

es. By offering their autonomous app-based transportation service in a single city (to start), Waymo is able to get to the functionality of Level 5 without getting the technology to level 5. Their "work around" here is to control, to a degree, the environment in which their vehicles operate. This ring-fenced introduction makes sense and makes the autonomous driving challenge easier to crack. Further, by offering a live consumer service they continue to learn; and the learning is the key to improving. Waymo and others are already working in other cities and given the current state of

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\* <https://www.cnet.com/roadshow/news/waymo-self-driving-cars-human-backup/>





the technology it is likely that they plan on introducing the autonomous driving service in various cities one at a time.

## Tesla

Tesla has taken an entirely different approach. Rather than operate a fleet of test vehicles, they have equipped all of the cars they sell<sup>12</sup> with the hardware for self-driving and the software that provides increasingly capable levels of, what they refer to as, autopilot. The capability is increased via over-the-air updates. The basis for these improvements is found in the fleet of cars, now approximating 500,000, which are sharing data—including video—used by Tesla to improve the auto-

nomous capability. Tesla is predicting it will have over one million vehicles on the road with self-driving hardware by the middle of 2020.<sup>12</sup> While Waymo is the acknowledged leader with autonomous testing miles with 10 million miles as of 2015, Tesla has accumulated over one billion miles of fleet miles driven in autopilot mode.<sup>14</sup>

Both of these firms believe they are close to offering transportation as a service using driverless vehicles. In April of 2019, Tesla's Elon Musk announced that Tesla would be operating a fleet of self-driving cars by 2020.<sup>15</sup>

Uber, Lyft and others are also working fever-



Image courtesy of Tesla

<sup>12</sup> Source: <https://www.wired.com/story/elon-musk-tesla-full-self-driving-2019-2020-promise/>

<sup>13</sup> Source: <https://www.geekwire.com/2019/tesla-elon-musk-robotaxi/>

<sup>14</sup> This figure comes from a recent filing with the State of California. See: <https://www.dmv.ca.gov/portal/wcm/connect/96c89ec9-aca6-4910-802b-c596f2625a7f/TeslaMotors.pdf?MOD=AJPERES&CVID=> Note that 400,000 vehicles with autopilot hardware averaging 1,000 miles per month would result in 400 million fleet miles added monthly. And, as mentioned, this fleet will be one million in 2020 which would generate one billion fleet miles per month.

<sup>15</sup> Source: <https://techcrunch.com/2019/04/22/tesla-plans-to-launch-a-robotaxi-network-in-2020/>



ishly on this challenge.

There is an industry debate regarding the timeframe for full level 5 autonomy. Some experts believe we're nearly at Level 5; BMW has stated it will offer Level 5 autonomy by 2021.<sup>16</sup> Others believe it is a "long way away."<sup>17</sup> The good news is that fully autonomous vehicles don't require Level 5 autonomy. According to ExtremeTech, "Most industry experts argue that by the time we get close to Level 5 most people will not own cars but will instead subscribe to a 'mobility service.'"<sup>18</sup>

Their argument is that Level 3 or 4 can provide autonomous service if the area is well "mapped and monitored." If this is true, we're on the cusp of autonomous service and a shift from the own and drive model to the transportation as a service model.

This vision of the future involves the two steps

we've outlined: cheaper EVs and technology advances allowing for autonomous driving converging with app-based transportation services, often referred to as ride sharing which results in Transportation as a Service (TaaS<sup>19</sup>). The cost of operating the average vehicle in the US approximates nearly \$10,000

per year.<sup>20</sup> The average household has two cars,<sup>21</sup> resulting in an average expenditure of \$20,000 per family. All this for a vehicle that is parked 95%<sup>22</sup> of the time!

The ability to "hail" an autonomous vehicle from your handheld

device and be transported to your destination all while saving thousands of dollars is a disruptive, game changing development. Stanford Professor Tony Seba believes the cost reduction coupled with the added convenience will change the own and drive model to the transportation as a service model. He believes this disruptive change will begin to

**The average household has two cars, resulting in an average expenditure of \$20,000 per family. All this for a vehicle that is parked 95% of the time!**

<sup>16</sup> Source: [https://www.thecarconnection.com/news/1120214\\_bmw-level-5-self-driving-car-could-happen-by-2021](https://www.thecarconnection.com/news/1120214_bmw-level-5-self-driving-car-could-happen-by-2021)

<sup>17</sup> Source: <https://www.nytimes.com/2018/11/27/business/self-driving-cars-autonomous-vehicles.html>

<sup>18</sup> Source: <https://www.extremetech.com/extreme/283632-self-driving-industry>

<sup>19</sup> Or, if you prefer, Mobility as a Service, MaaS.

<sup>20</sup> The American Automobile Association (AAA) calculates the average annual cost of an automobile to be \$8,849. This estimate is for 2018 and includes fuel, maintenance, repairs, insurance, license/registration/taxes, depreciation and loan interest. It does not include parking. One study published by City Observatory has the cost to park annually at \$1,440. INRIX calculates the average annual cost of parking in the US at \$1,607. Never mind that American drivers spend 17 hours a year searching for parking spots. Adding the average parking cost to the average annual operating cost gets to an average above \$10,000. See: <https://newsroom.aaa.com/auto/your-driving-costs/> and <http://cityobservatory.org/the-price-of-parking/> and <http://inrix.com/press-releases/cod-us/> and <https://www.usatoday.com/story/money/2017/07/12/parking-pain-causes-financial-and-personal-strain/467637001/>

<sup>21</sup> Source: <https://www.statista.com/statistics/551403/number-of-vehicles-per-household-in-the-united-states/>

<sup>22</sup> A number of studies come to this estimate, StreetsBlogUSA has an informative discussion of the various studies and methodologies. <https://usa.streetsblog.org/2016/03/10/its-true-the-typical-car-is-parked-95-percent-of-the-time/> See also <http://fortune.com/2016/03/13/cars-parked-95-percent-of-time/>





happen extremely rapidly and will essentially be complete by 2030<sup>23</sup> with 95% of all US passenger miles served by transportation as a service model in 2030.<sup>24</sup> This preference for service vs ownership is important because it directly impacts the EV vs. ICE debate. If Tony

Seba's 95% forecast by 2030 is correct then EV's as a percentage of new car sales may well approach 90% by 2030.

And then there's...

### The Flying Car

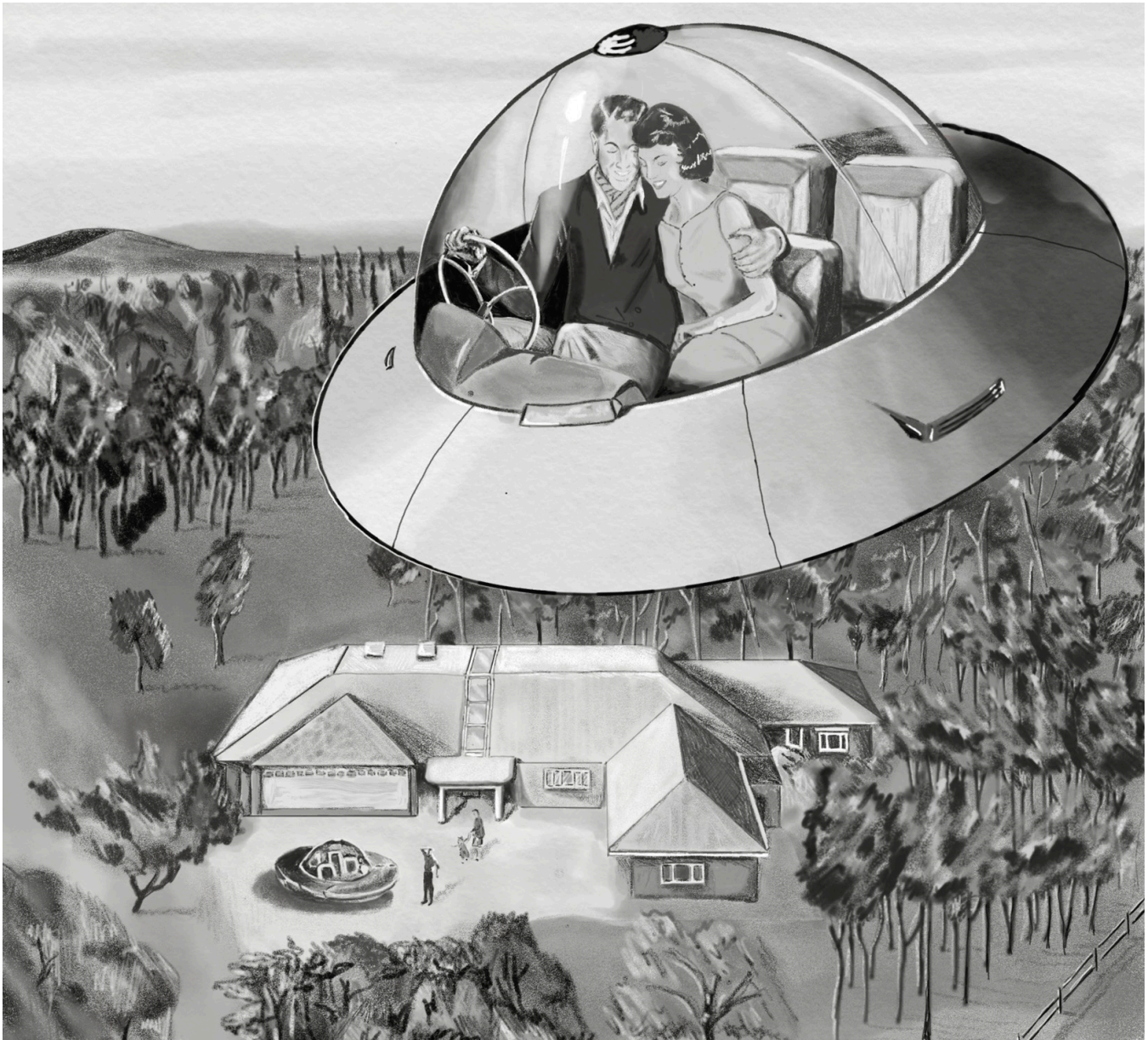


Image courtesy of SmartETFs

<sup>23</sup> See Tony Seba's 2018 presentation on YouTube Clean Disruption: Why Conventional Energy and Transportation will be Obsolete by 2030 <https://www.youtube.com/watch?v=TRcx-btcle4>.

<sup>24</sup> Rethinking Transportation 2020-2030, James Arbib and Tony Seba. [https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/59f279b3652deaab9520fba6/1509063126843/RethinkX+Report\\_102517.pdf](https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/59f279b3652deaab9520fba6/1509063126843/RethinkX+Report_102517.pdf)



While it may be hard to believe, the self-flying, electric vehicle may be here in the next few years. Approximately 70 companies including Airbus, Boeing, Intel, Bell Helicopter and EHang<sup>25</sup> are reportedly developing or conducting test flights of flying cars. Uber has stated it plans to begin testing flying taxis in Los Angeles and Dallas as early as 2020, and is targeting a service offering by 2023.<sup>26</sup> Boeing believes they can have their autonomous flying car, which has a range of 50 miles, in service as early as 2023.<sup>27</sup> As with the autonomous car, the flying car will likely be deployed as a service. Booz Allen has predicted that flying taxis could ferry 80,000 riders each day in the United States.<sup>28</sup> Clearly there are numerous technical, regulatory and infrastructure issues to be sorted out but airborne transportation as a service fulfills the promise of the 1950 vision of the future which is depicted in the prior illustration.

In some ways the flying taxi may be an easier technological challenge than self-driving cars as there are fewer obstacles to deal with. Morgan Stanley has forecasted that the size of this market could reach between \$615 billion and \$2.9 trillion by 2040.<sup>29</sup>

**Instead of expensive large buses running with less than ideal frequency, imagine a city where smaller buses came by with great frequency.**

### **But Wait...There's More**

Until this point, we've ignored public transportation in this equation. Autonomous electric vehicles have the potential to completely transform public transportation by allowing it to serve more consumers and provide a higher level of service. In most American cities public transportation is failing to serve a high enough percentage of the population to meet the objectives of urban planners. This failure has more to do with the public transportation model than with the concept of public transportation.

City buses tend to be large and expensive. The large expensive bus is mainly a function of the expense of the driver. The expense of the buses and drivers means fewer buses which translates to slower and less frequent service. Fewer buses and slower service inherently

<sup>25</sup> See this April 28, 2019 article at CleanTechnica on EHang's flying taxi. Be sure and watch the video demo: <https://cleantechnica.com/2019/04/28/ehang-shows-dazzled-public-its-autonomous-evtol-aircraft/>

<sup>26</sup> Los Angeles Times, February 24, 2019. Online version: <https://www.latimes.com/business/la-fi-flying-cars-20190222-story.html>

<sup>27</sup> Los Angeles Times, January 24, 2019. Also see: [www.boeing.com/features/2019/01/pav-first-flight-01-19.page](http://www.boeing.com/features/2019/01/pav-first-flight-01-19.page)

<sup>28</sup> Los Angeles Times, February 24, 2019. Online version: <https://www.latimes.com/business/la-fi-flying-cars-20190222-story.html>

<sup>29</sup> LA Times January 24, 2019.







Image courtesy of TransDev

reduces the utility value for consumers. Instead of expensive large buses running with less than ideal frequency, imagine a city where smaller buses came by with great frequency. Public transit could also utilize app-based ride requests which would mean a bit of a hybrid between public transportation and transportation as a service. Combining the app-based concept with public transit could enhance the service level of public transportation. Using the app, riders indicate both their pick up and drop off stops. The cloud-based software tells the passenger to wait an extra minute for a specific bus and alerts the autonomous bus to stop at the rider's stop. This results in the efficient clustering of passengers by destination and means fewer stops and faster transit times. Recall our point above about ringfencing the autonomous transportation as

a service being deployed by Waymo in Phoenix. The restriction of the known route works even better for buses which are only required to operate along a specific, predefined route. Because the known route presents a lesser technological challenge, we believe autonomous vehicles have the ability to gain traction quickly in the public transit sector. And indeed, such service is in operation today. The adjacent photo shows an example of a smaller, autonomous electric bus which is currently in operation in Florida.

### Automobile Safety

The AV offers significant potential to save lives. There are approximately 1.25 million traffic deaths annually,<sup>30</sup> about 35,000 of which are in the US.<sup>31</sup> The National Traffic Highway Safety Administration found that "94% of serious

<sup>30</sup> Source: World Health Organization. [https://www.who.int/gho/road\\_safety/mortality/en/](https://www.who.int/gho/road_safety/mortality/en/)

<sup>31</sup> Source: Insurance Institute for Highway Safety. <https://www.iihs.org/iihs/topics/t/general-statistics/fatalityfacts/state-by-state-overview> Note that US auto fatalities have been declining in absolute terms. In 2007 there were approximately 41,000 US traffic fatalities. (Department of Transportation <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811059>). US traffic fatalities were commonly in the 50,000 range throughout the 1970s and into the 1980s.

<sup>32</sup> Source: <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>. It's slightly more complicated than one might assume. The DOT found 6.8% of vehicles involved in accidents had one or more "adverse vehicle conditions." Adverse conditions can compound human error but might not necessarily cause an accident without human error. The DOT study found that 88.2% of vehicles involved in accidents had no adverse vehicle conditions. <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811059>



There are approximately 1.25 million traffic deaths annually, about 35,000 of which are in the US. The National Traffic Highway Safety Administration found that “94% of serious crashes are due to human error.” These human errors include not paying attention (40%), poor decision making (34%), poor driving (34%), and “actually asleep” at the wheel (2%).

crashes are due to human error.<sup>32</sup> These human errors include not paying attention (40%), poor decision making (34%), poor driving (34%) and “...actually asleep” at the wheel (2%). Some projections imply AVs will eliminate all human error automobile accidents; essentially projecting a 94% reduction in accidents and fatalities.<sup>33</sup> While AVs don’t get distracted and

don’t drink and drive, we don’t believe AVs will have perfect safety records. An analysis of Waymo’s safety record released in 2015 showed that Waymo, with two million miles of autonomous driving at that time (they’re now over 10 million miles), had had only one “at fault” accident, “...about 10 times lower than the safest demographic of human drivers.”<sup>34</sup> Oddly, however, their cars were involved in slightly more accidents per mile than average overall. The authors of the report believed this was because the Waymo self-driving vehicles are driving “too safely,” obeying all traffic laws. In essence, the Waymo vehicles were behaving in a manner that human drivers didn’t expect.

In a report filed by Tesla with the State of California in in December of 2018, Tesla noted that the number of accidents involving their vehicles in the third quarter of 2018 with the autopilot engaged is “...one crash for every 3.34 million miles driven...” versus one crash for every 1.92 million miles for all Tesla vehicles.<sup>35</sup> Tesla’s autopilot isn’t full autonomy, although some drivers seem to be confident enough to use it as such. There have been multiple news reports about drivers sleeping while at the wheel of a Tesla.<sup>36</sup>

<sup>33</sup> See this article from the Atlantic: <https://www.theatlantic.com/technology/archive/2015/09/self-driving-cars-could-save-300000-lives-per-decade-in-america/407956/> or this article from ZD Net <https://www.zdnet.com/article/how-autonomous-vehicles-could-save-over-350k-lives-in-the-us-and-millions-worldwide/>

<sup>34</sup> How Safe Are Self-Driving Cars? Jeruld Weiland and Allison Crowe, Rocky Mountain Institute, [https://www.huffingtonpost.com/entry/how-safe-are-self-driving-cars\\_us\\_5908ba48e4b03b105b44bc6b](https://www.huffingtonpost.com/entry/how-safe-are-self-driving-cars_us_5908ba48e4b03b105b44bc6b)

<sup>35</sup> Source: <https://www.dmv.ca.gov/portal/wcm/connect/96c89ec9-aca6-4910-802b-c596f2625a7f/TeslaMotors.pdf?MOD=AJPERES&CVID=>

<sup>36</sup> Here’s a link to one such report: <https://electrek.co/2019/01/19/tesla-autopilot-driver-sleeping-video/>



The current available data set makes it difficult to make any projections on the safety gains and we doubt that AVs will eliminate all accidents. That said, the safety gains may mean a 70% to 90% reduction in accidents.<sup>37</sup> Even if the accident reduction is less than that, AVs have the potential to save hundreds of thousands of lives.

### The Traffic Question

What could AVs and transportation as a service mean for traffic congestion? The short answer is, it's complicated.

Autonomous transportation as a service will likely result in more trips per person. Experts believe that current ride sharing

services have increased

traffic in urban centers in part because they are diverting commuters from public transportation. In addition, autonomous vehicles will be driving without passengers some of the time. Despite all of this, it is probable that AVs and transportation as a service will reduce traffic congestion and reduce transit times.

This is somewhat dependent on the implementation but here are some of the elements behind a prediction of reduced traffic congestion.

AVs have the potential to save hundreds of thousands of lives.

- **Connectivity:** Vehicle to Vehicle Connectivity (V2V) and Vehicle to Everything Connectivity (V2X) allow vehicles to communicate with each other and with other elements of their environment, including roadway infrastructure, traffic signals, and potentially pedestrians.<sup>38</sup> Connectivity could allow for a coordination between vehicles and signals allowing for smaller gaps between automobiles and for quicker response times both for starting and stopping. Narrower gaps result in a smoother flow of traffic. This could curtail

phantom traffic jams which result from a few cars stopping and then a lengthy delay as cars sequentially begin moving again.<sup>39</sup>

- **More traffic lanes:** Space currently devoted to curbside parking can be devoted to additional traffic lanes.

- **Ride sharing for real:** Ride sharing has become synonymous with transportation as a service. But a single party travelling with a Uber or Lyft driver isn't really ride sharing. If the implementation of driverless cars involves a meaningful measure of ride sharing—by which we mean multiple parties in a vehicle—

<sup>37</sup> Samuel Schwartz believes the reduction in accidents, fatalities and injuries "...could be 70%..." See No One at the Wheel, page 134.

<sup>38</sup> There a host of other V2's including V2I (Vehicle to Infrastructure) and V2P (Vehicle to Pedestrian). A good explanation can be found here: <https://www.geotab.com/blog/connected-vehicle-technology/>

<sup>39</sup> The US Department of Transportation was drafting rules for the implementation of V2V technology in late 2016. However, the Administration has put this initiative on hold.

this would help reduce congestion.

- **Improved public transportation:** Autonomous electric buses should be small, quicker and more frequent. This should both improve the ability of buses to move with the flow of traffic and, importantly provide a vastly superior product for commuters. And while this will increase the number of buses, albeit smaller in size, it should reduce the dependency on single rider automobiles.

- **Bicycle and electric scooter services** are gaining traction and these “last mile” solutions fit neatly into the transportation as a service model and reduce the number of automobiles in use.<sup>40</sup>

- **Flying taxis:** Flying taxis could remove some of the pressure off the urban streets.

Much of this technology won't be in place at the beginning of the smart transportation revolution, but over time we believe the integration of these elements will reduce transit times and traffic congestion.

### A Few Words About the Vehicles

The depiction of a self-driving car on page one of this report is illustrative of how difficult it can be to predict the future. The car depicted sports the interior of automobiles from the

mid-1950s.<sup>41</sup> In a similar fashion, we've seen contemporary depictions of autonomous vehicles that look a lot like existing automobiles but without the steering wheel. More likely is that the autonomous vehicle revolution will involve a complete reshaping of vehicles. Autonomous vehicles will no longer need to be built around the driver. The AV of tomorrow will likely be built around the functionality on the inside. Perhaps a sitting area, a desk, and place for internal storage instead of a trunk. Some will be luxurious and others more utilitarian. They will likely be much easier to enter than current vehicles. We envision cars with elevator type sliding doors tall enough to enable passengers to simply step into the vehicle in a standing or near standing position as we believe that transportation as a service will likely put a premium on fast ingress and egress, both for the convenience of the passengers and the efficiency of the service provider. Such a configuration also aids those that have limited mobility. Then too, EV technology means that large engine compartments will be replaced with smaller electric motors that don't require a space hogging transmission. All of this suggests a taller rectangular shape.

### Implications of the Smart Transportation Revolution

There is always some difficulty in trying to predict how society and regulators will adapt

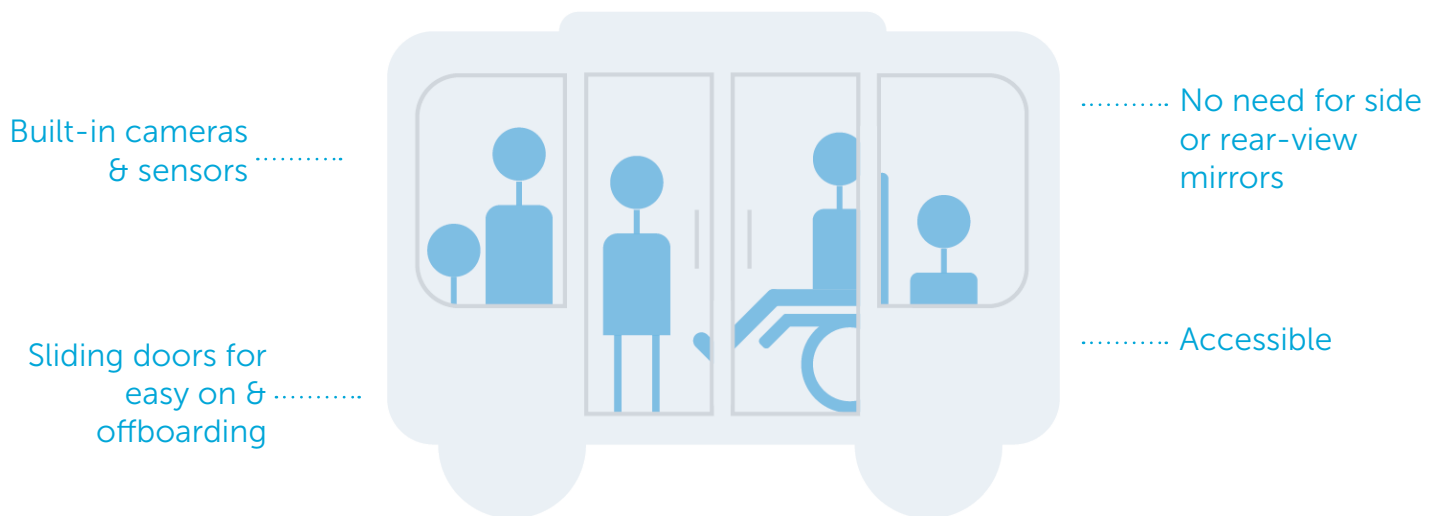
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<sup>40</sup> Uber has integrated traffic conditions into its app traffic conditions and a feature that helps users decide whether they should use an Uber automobile or another form of Uber transit, specifically an electric Uber bicycle or public transit with the ticket purchase via the Uber app. See: <https://techcrunch.com/2018/09/16/uber-traffic/>

<sup>41</sup> And, of course, the family is sporting the latest in 1950's style and playing a board game. Not one handheld device in sight.



# The Anatomy of the AV



to major change. There is a risk that the public will fail to accept autonomous vehicles or that regulatory bodies will inhibit the deployment of AVs. However, assume that the vision contemplated here is correct and that the autonomous/EV ride sharing model coupled with significantly superior public transportation replaces a meaningful percentage of the individually owned and operated transportation model. Here are some of the implications of the coming revolution.

## Land Use, Urban Planning and the Environment

One obvious benefit that may accrue is the freeing up of parking spaces both in homes and in urban centers. This includes both curbside parking and parking lots, whether multi-level or surface. "Parking accounts for as much as 24% of the area in American cities..."<sup>42</sup> The smart transportation revolution could also

free up 168,000 gas stations in the US alone.<sup>43</sup> Humans generally will benefit from the smart transportation revolution. EVs are significantly more efficient than ICE vehicles meaning that even if they use fossil fuel-based electricity EVs pollute significantly less than ICE vehicles. Additionally, over time we believe electricity will be produced from solar or wind power which means zero emission driving. We've already discussed the savings of hundreds of thousands of lives now being lost to traffic accidents. Add to this the elimination of time wasted in traffic, driving and looking for parking spaces. And if there is a renaissance in public transportation and the reduced cost for autonomous transportation as a service, travelers with limited mobility and travelers on a limited budget will benefit. All of this implies a big win for society.

<sup>42</sup> Source: <https://www.intellias.com/self-driving-car-save-money/>

<sup>43</sup> Source: US Department of Energy <https://www.fueleconomy.gov/feg/quizzes/answerQuiz16.shtml>

## Economic Implications

There will inevitably be winners and losers as a result of the smart transportation revolution. The shift to autonomous electric vehicles and transportation as a service is a disruption that could have a large impact on the economy. Perhaps the biggest economic winners will be consumers as they may save \$700 billion per year (approximately \$3,000 per household)<sup>44</sup> on transportation just in the US. These savings can be put to use in other parts of the economy.

### Retailers

Retailers may come out as winners. It's easy to see that online retailers will benefit from cheaper delivery costs and households with an additional \$700 billion of disposable income available. But, local retailers will suddenly have the advantage of proximity coupled with cheap and quick deliveries. This may be of particular relevance to grocery stores; as we discuss below, autonomous delivery of groceries is already underway. Whether the smart transportation revolution favors online over local retailers is open for debate, but the retail industry overall could be a surprising beneficiary.

### Tech

The tech industry will likely be another big beneficiary of the smart transportation revolution.

The following products and services are key to operating and managing the smart transportation revolution:

- Semiconductors
- Artificial intelligence
- Cameras
- Sensing equipment
- Mapping and guidance software
- Communication equipment and services

Companies that are able to provide these products and services will be well placed, however, it must be noted that there will be fierce competition and rapid technological improvement

which makes it difficult to know which specific companies and technologies will succeed.

### Shipping

Another winner may be the shipping/freight industry. This industry should see their profit margins and shipping volume increase given the lower cost of shipping due to the autonomous driving (which eliminates the need for the driver<sup>45</sup>) and also to the lower cost of operation of electric trucks. One report forecasts a savings of \$300 billion for the trucking industry.<sup>46</sup>

### Automobile Manufacturers

Automobile manufacturers will need to navigate through a lot of potential changes including the transition to EVs which involves

<sup>44</sup> RethinkX's estimate for total annual US consumer savings is \$1 trillion. See Rethinking Transportation 2020-2030. [https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/59f279b3652deaab9520fba6/1509063126843/RethinkX+Report\\_102517.pdf](https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/59f279b3652deaab9520fba6/1509063126843/RethinkX+Report_102517.pdf)

<sup>45</sup> There are 3.5 million truck drivers in the US and it is natural to be concerned about their livelihoods. The good news is that it is not clear that all 3.5 million truckers will be displaced. The trucking industry supports 8.7 million jobs which include dispatch, loading, logistics etc. Autonomous trucking will likely reduce shipping costs which should result in more shipping which may well result in the creation of more non-driver jobs within the industry. Also of note, the WSJ May 22, 2019 article on the US Postal Service and TuSimple testing self-driving trucks cites a shortage of drivers willing to drive these routes as one reason they are conducting the test. Source for the job statistics: <http://www.alltrucking.com/faq/truck-drivers-in-the-usa/>

<sup>46</sup> Source: <https://www.truckinginfo.com/143139/report-autonomous-vehicles-could-save-trucking-300-billion-in-labor-costs>





writing off decades of skills learned in manufacturing 2,500 moving parts in the internal combustion engine and potential changes in their business model as consumers shift to transportation as a service. To varying degrees, automobile manufacturers are aware of this coming disruption.<sup>47</sup> Some automobile manufacturers are contemplating a day when they may need to offer transportation as a service, wondering if they should compete with the likes of Waymo, Lyft and Uber. A difficulty here is that there may only be a few ride sharing providers if this industry is subject to the network and winner takes all effects—users will likely have a limited number of apps/accounts set up on their phones and the service providers need to have sufficient vehicles in the vicinity of the riders.

## Electric Utilities

Electric utility companies may well be short-term winners as a rapid EV adoption rate will increase electricity demand. This may only be short-term, however as batteries and solar panels continue to fall in costs and they in turn become a disruptive threat to electricity generators and distributors.<sup>48</sup>

## Automobile Insurance

The automobile insurance industry will need to come to grips with the potential dramatic changes in the wake of the smart transportation revolution. Autonomous fleet operators will likely need some form of liability insurance but transportation as a service could well mean far fewer individual owners of vehicles. Further, if the safety gains are anywhere close to the 70%

to 90% range then the cost of insurance will be significantly lower than at present. These changes could mean a radical redesign of the insurance market both in terms of delivery and size.<sup>49</sup>

## Automobile Finance

The automobile finance industry may suffer from the transition to smart transportation. The switch to EVs and AVs may have a meaningful negative impact on used non-AV and non-EV car values. As AVs are introduced, non-autonomous vehicles will experience technological obsolescence. This could mean significant reductions in value versus the current expected residual value.<sup>50</sup>

<sup>47</sup> You can read what Ford has to say about the smart transportation revolution here: [https://social.ford.com/en\\_US/story/ford-community/move-freely/the-future-of-transportation-is-driverless-shared-and-networked.html](https://social.ford.com/en_US/story/ford-community/move-freely/the-future-of-transportation-is-driverless-shared-and-networked.html) Also note that Ford has entered the electric scooter service market. See <https://www.azcentral.com/story/news/local/mesa/2019/02/16/ford-motor-co-spin-scooters-make-first-arizona-roll-out-mesa/2882492002/>

<sup>48</sup> The discussion of utility companies is somewhat complex. Utility companies are beginning to utilize battery storage and solar (and wind) generation in favor of construction of “peaker plants.” The declining costs of these technologies are, for the moment, cost savers to the utility industry. These same declining costs represent a competitive threat to the industry. How this plays out over the coming decades is difficult to predict.

<sup>49</sup> See this interesting Bloomberg article: <https://www.bloomberg.com/news/articles/2019-02-19/autonomous-vehicles-may-one-day-kill-car-insurance-as-we-know-it> Or this from the Insurance Journal which cites an Accenture report which sees a \$25 billion dollar decline in insurance premiums but an offsetting opportunity for new forms of insurance for the AV marketplace. <https://www.insurancejournal.com/news/national/2018/11/20/509751.htm>

<sup>50</sup> Not to alarm our readers, but it could be worse than that. RethinkX believes 100 million vehicles might simply be abandoned as they become economically unviable. (See Rethinking Transportation 2020-2030). For information about possible declines in residual value see Auto Finance News, March 29, 2018 <https://www.autofinancenews.net/remodeling-residuals-as-autonomous-technology-matures-will-todays-cars-face-a-steep-residual-drop/>



## The Future is Here

Change is afoot and the key is the timeline. Autonomous vehicles and transportation as a service are already in use, albeit in the early stages of deployment. We've mentioned that Waymo is already transporting riders via autonomous vehicles in Phoenix. Lyft is working with Aptiv PLC in Las Vegas where they have 30 autonomous vehicles in operation.<sup>51</sup> Autonomous vehicles operated by Waymo, Uber and others are also in use in limited areas in other cities in the US. Separately, Tesla has stated that their auto pilot feature will be upgraded by the end of 2019 to provide automatic driving on city streets including responding to stop signs and traffic signals<sup>52</sup> and

that they will have a million self-driving robotaxis in operation by 2020. Transdev is operating on-demand transport services in Rouen, France, albeit in three limited areas. Transdev has been offering autonomous public transportation since 2005 and has already transported 3.5 million passengers autonomously.<sup>53</sup> Las Vegas, Gainesville and Detroit are three cities with autonomous buses serving passengers. Navya, a French company is offering fully automated taxis and shuttles for sale. Their shuttles are already in use in a number of cities.<sup>54</sup>

Smart transportation isn't just for humans; various firms are already offering delivery of



Image courtesy of TuSimple

<sup>51</sup> Wall Street Journal February 12, 2019.

<sup>52</sup> Source: <https://electrek.co/2019/02/28/automatic-driving-city-stop-signs/>

<sup>53</sup> Source: <https://www.transdev.com/en/our-innovations/shared-autonomous-mobility/>

<sup>54</sup> Here is a link to their site: <https://navya.tech/en>. You can see they have information on how to purchase their autonomous taxi. We're not sure when delivery is but the clear suggestion is that they're waiting for you to place your order.



food, beverages and groceries via autonomous drones. Nuro is delivering groceries in Arizona using an unmanned vehicle driving on city streets. Using this service, shoppers purchase groceries and the delivery vehicle drives to their location where the shopper enters their pin and the door to a compartment containing their purchase opens.<sup>55</sup> Kiwi is making deliveries with autonomous bots in Berkeley, California. The company claims to have made over 10,000 deliveries to date.<sup>56</sup> FedEx has announced that they will be making autonomous deliveries with what they refer to as SameDay Bots before the end of 2019.<sup>57</sup>

Numerous trucking companies are already testing autonomous big rigs on public highways including TuSimple<sup>58</sup> and Embark, which have been testing an automated big rig along a 650 mile stretch of Interstate 10 from Texas to California. TuSimple and the US Postal system are also testing self-driving trucks along a 1,000 mile stretch of highway between Phoenix and Dallas.<sup>59</sup> In Sweden, Einride AB is testing a fully self-driving truck on public roads. The Einride tests do not involve a human in the cab since these trucks don't have steering wheels.<sup>60</sup> The challenges for highway travel, particularly on a known, predefined

route represent a smaller technological challenge than Level 5 autonomy and, as a result, will likely mean interstate trucking companies may be among the first to utilize autonomous vehicles.<sup>61</sup>

Another example of coming smart transportation that may be on the horizon is the hyperloop, a high-speed mode of ground transportation which involves a vacuum tube and magnetic levitation. At least three companies, including Virgin Hyperloop One, are in various stages of testing the technology which offers the possibility of 500 plus miles per hour speeds. According to the NY Times, "Passenger operations could begin by the middle of the next decade."<sup>62</sup>

### Alternate Visions

The vision of the future laid out here may not come to pass either in the time or manner that we envision. One area where it may be wrong is in the view that the transportation as a service model will largely replace the own and drive model. This element is important because it directly affects the speed with which EVs replace ICE vehicles. Fleet operators should be much more aggressive in their adoption of EVs than individual consumers

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<sup>55</sup> See this site <https://nuro.ai/> which contains a video worth watching. Also see the Wall Street Journal February 12, 2019. Also see the New York Times December 20, 2018.

<sup>56</sup> See the Kiwi bots in action on the Kiwi Campus site: <https://kiwicampus.com/>.

<sup>57</sup> Source: <https://about.van.fedex.com/newsroom/thefuturefedex/>

<sup>58</sup> Source: <https://techcrunch.com/2019/01/07/autonomous-trucking-startup-tusimple-is-taking-3-to-5-commercial-trips-a-day/>

<sup>59</sup> Wall Street Journal, May 22, 2019.

<sup>60</sup> Wall Street Journal, May 22, 2019 and CNN: <https://www.cnn.com/2019/05/15/tech/einride-self-driving-trucks/index.html?sr=twCN-N051519einride-self-driving-trucks0156PMVODtop>

<sup>61</sup> See the New York Times, November 13, 2017 <https://www.nytimes.com/2017/11/13/business/self-driving-trucks.html>

<sup>62</sup> New York Times, February 19, 2019. The idea behind the hyperloop has been around since the 1800s and has been revived and promoted by Elon Musk.



because they have a strong financial incentive to pursue EVs. As mentioned, at the moment the higher upfront cost for an EV will keep many consumers from choosing an EV. We still see EVs gaining significant market share; the question is simply how quickly that occurs.

Quite possibly, autonomous driving technology may either take longer to reach a sufficient level of capability to allow for the deployment of self-driving cars and autonomous ride sharing, or there may be legal and regulatory setbacks that lead to a delay in implementation. Public acceptance of self-driving cars may take longer than expected. Additionally, the technology and support systems that underpin autonomous vehicles has yet to be proven and may fail to develop in a timely manner.

In the long run, however, the direction of travel seems quite likely towards the adoption of EVs, AVs and transportation as a service.

## Conclusion

We live in an era of rapid and profound change. The smart transportation revolution represents change that has the potential to affect everyone. We know that massive changes can occur in a very short period of time. We know that some changes can disrupt entire industries and touch the lives of virtually every human. Change can be both exciting and difficult. It can also represent opportunity to those that are able to understand the implementation and effects of change. The SmartETFs Smart Transportation & Technology ETF (MOTO) is designed to capitalize on the coming smart transportation revolution, however it unfolds.



## Important Information

The SmartETFs Smart Transportation & Technology ETF will invest in publicly-traded equity securities of domestic or foreign companies that are involved in the development and production of products or services for Smart Transportation, including safer, cleaner or connected vehicles and Smart Transportation companies providing “transportation as a service.” The Fund will also invest in Technology companies, including Technology companies whose products or services are used in transportation.

The SmartETFs Smart Transportation & Technology ETF trades on the NYSE, symbol MOTO.\*

The Fund is an actively managed exchange-traded fund. Actively managed means that the Adviser will select the Fund holdings. Shares of ETFs are bought and sold at market price (not NAV) and are not individually redeemed from the Fund. Brokerage commissions will reduce returns.

Fund investing involves risk Principal loss is possible.

\* These risks could adversely affect the value of companies in which the Fund invests. Limitations on applications for autonomous or electric vehicles could adversely affect the value of companies in which the Fund invests.

Investments in foreign securities involve greater volatility, political, economic and currency risks and differences in accounting methods. These risks are greater for emerging markets countries. Non-diversified funds concentrate assets in fewer holdings than diversified funds. Therefore, non-diversified funds are more exposed to individual stock volatility than diversified funds. Funds concentrated in a specific sector may be subject to more volatility than a more diversified investment.

The companies in which the Fund invests may be subject to rapid changes in technology, intense competition, rapid obsolescence of products and services, loss of intellectual property protections, evolving industry standards and frequent new product productions and changes in business cycles and government regulations.

The prospectus contains more complete information including investment objectives, risks, fees and expenses related to an ongoing investment in the Fund. Please read it carefully before investing. A prospectus can be obtained by calling 866-307-5990 or at [www.SmartETFs.com](http://www.SmartETFs.com). Read the prospectus carefully before investing.

The Fund is distributed by Foreside Fund Services, LLC.



## Additional Resources

We've provided extensive footnotes which contain details on our sources as well as some additional commentary. If you wish to research these topics these footnotes should prove of some value. Below is a more manageable list of some of our recommended resources.

Tony Seba has a number of presentations available on YouTube. One of our favorites is *Clean Disruption of Energy & Transportation*. This presentation is just over one hour but be warned; the first 59 seconds are so compelling that you'll be hooked. Without giving anything away, his first two illustrations set up his talk brilliantly. <https://www.youtube.com/watch?v=2b3ttqYDwF0>

There is also a book, *Clean Disruption of Energy and Transportation* which is worth the read.

James Arbib and Tony Seba of RethinkX produced a May 2017 report, *Rethinking Transportation 2020-2030* that is highly recommended. This RethinkX report presents the most detailed and optimistic view of the smart transportation revolution we've encountered. [https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/59f279b3652deaab9520fba6/1509063126843/RethinkX+Report\\_102517.pdf](https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/59f279b3652deaab9520fba6/1509063126843/RethinkX+Report_102517.pdf)

Robin Chase, ZipCar cofounder, has a very interesting article in Wired that is worth reading from a public policy standpoint. We mention above that we believe smart transportation can reduce traffic congestion and transit time with the caveat that the implementation is important. This article highlights the need for smart implementation. <https://www.wired.com/2016/08/self-driving-cars-will-improve-our-cities-if-they-dont-ruin-them/>

The Last Driver License Holder is an excellent blog covering autonomous driving worth checking out at <https://thelastdriverlicenseholder.com/>.

Samuel Schwartz has an excellent book, *No One at the Wheel* that is an important read on the topic. Schwartz was an urban planner in NY City (he's credited with coining the phrase "grid lock") and he has an interesting perspective on self-driving vehicles.

Electrek is an excellent source of news regarding electric vehicles. <https://electrek.co/>



EVAoption is also an excellent source of news and views on the adoption of electric vehicles.  
<https://evadoption.com/>.

Waymo has a great video which shows, in 360 degrees, the experience of driving in an autonomous vehicle. <https://waymo.com/360experience>

The Nuro unmanned delivery vehicle can be seen at a video on Nuro's site: <https://nuro.ai/>

For an informative podcast on autonomous vehicles see Marc Hoag's Autonomous Vehicle podcast at <https://marchoag.com/>.

Professor Alain Kornhauser of Princeton University produces a podcast and newsletter, Smart Driving Cars. The content here is correctly described as being, "On the more technical side." Of interest, Professor Kornhauser is as strong advocate for autonomous vehicle technology being used to aid the mobility disadvantaged. <http://smartdrivingcar.com/>

We also recommend the Mobility Podcast which can be found here: <https://www.mobilitypodcast.com/>

Tesla put on a lengthy and detailed presentation called Tesla Autonomy Day on April 22, 2019. If you're interested in the topic this is well worth the time to watch. The presentation provides details on their onboard computer, neural network, the software, hardware and their vision of the robotaxi. <https://www.youtube.com/watch?v=Ucp0TTmvqOE>.