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A Culture/Climate Examination of Autonomous Vehicle Technology In The United States

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A Culture/Climate Examination of Autonomous Vehicle Technology in the United States

by

James J. Mennie

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Business Administration Department of Business Muma College of Business University of South Florida


Date of Approval: December 7, 2018

Keywords: Connected Vehicle, Lidar, Artificial Intelligence, Radar

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# TABLE OF CONTENTS

Table of contents ........................................................................................................ i  

List of Tables ................................................................................................................ iii  

List of Figures ................................................................................................................ iv  

Abstract .......................................................................................................................... vi  

Chapter 1: Industry Analysis: An Examination of Autonomous Vehicle Technology ..........1  
Industry Analysis: An Examination of Autonomous Vehicle Technology .......................1  
   Tagline .........................................................................................................................1  
   Keywords .....................................................................................................................1  
   Executive Summary ....................................................................................................1  
Industry Analysis: An Examination of Autonomous Vehicle Technology .......................3  
   Introduction ................................................................................................................3  
   The Industry ................................................................................................................4  
   Stakeholders ..............................................................................................................5  
   Methods .......................................................................................................................5  
   Background ...............................................................................................................5  
History of Autonomous Vehicle Technology ................................................................9  
   Tesla .........................................................................................................................11  
   Waymo ......................................................................................................................12  
   Voyage ....................................................................................................................12  
   GM ............................................................................................................................12  
   Ford ...........................................................................................................................13  
Law & Liability .............................................................................................................14  
Safety ............................................................................................................................15  
Cybersecurity ...............................................................................................................16  
Terminology ..................................................................................................................17  
Discussion ....................................................................................................................18  
Conclusion .....................................................................................................................18  

Chapter 2: Industry leaders share their thoughts on Autonomous Vehicle technology and it’s expected societal benefits within the United States.................................................20  
Industry leaders share their thoughts on Autonomous Vehicle technology and it’s expected societal benefits within the United States.................................................20  
   Tagline .......................................................................................................................20
LIST OF TABLES

Table 1: Listing of Autonomous Vehicle Proving Ground Designees .......................... 7
Table 2: Important Milestones in the history of Autonomous Vehicle Technology .......... 9
Table 3: Five Eras of Safety .................................................................................. 15
Table 4: Critical Autonomous Vehicle Technology terms & definitions ..................... 17
LIST OF FIGURES

Figure 1: Society of Automobile Engineers, Level of Automation 2014 (Adopted by DOT) ….. 4
Figure 2: USDOT 10 Autonomous Vehicle Proving Ground Designees ............................... 7
Figure 3: Connected Vehicles – CV pilot Tampa ................................................................. 8
Figure 4: Schematic of sensors deployed in vehicles and infrastructure .............................. 8
Figure 5: History of Autonomous Vehicle Technology ......................................................... 11
Figure 6: Interviewee Responses to “Will A/V lead to greater productivity? ....................... 30
Figure 7: Tree Map of Top fifteen terms “Will A/V lead to greater productivity? ............... 31
Figure 8: Word Summary – Frequency and weighed percentage of Node – “Will A/V lead to greater productivity? ................................................................. 32
Figure 9: “How will American’s daily routine change with Autonomous Vehicle Technology? ............................................................................................................ 32
Figure 10: Tree Map of Top 10 words query from “How will American’s daily routine change with Autonomous Vehicle Technology? ..................................... 33
Figure 11: Word Summary – Frequency and weighted percentage of Node, “How will Americans daily routine change with Autonomous Vehicle Technology? ........ 33
Figure 12: Do you anticipate job losses due to A/V technology? ........................................ 34
Figure 13: Tree Map – Top 10 words “Do you anticipate job losses due to A/V technology? ... 35
Figure 14: Word Summary – Frequency and weighted percentage of Node, “Do you anticipate job losses due to A/V technology? ..................................................... 35
Figure 15: United Nations World Health Organization (2015) ............................................. 67
Figure 16: Mass Adoption of Autonomous Vehicle ........................................... 69

Figure 17: Roof of personal vehicle with connected technology & enhanced rear-view mirror ....................................................................................................................... 71
ABSTRACT

Autonomous Vehicle are coming. But mass adoption is at least ten years away according to consensus compiled from interviews conducted with industry thought lenders. Questions remain as to what technology those vehicles will contain as there is no universal platform for autonomous vehicle technology, since manufactures, hardware and software companies are developing their own proprietary products. A/V technology is expected to improve productivity, and provide a plethora of societal benefits, but while we await the closure of the time gap the US will lose almost 40,000 citizens each year with traffic fatalities.

Connected vehicle technology, which is currently completing pilot studies, has been shown to reduce automobile accidents. This technology is not as complex as autonomous vehicle technology and is available now. Semi-autonomous vehicles which is Level 1 through Level 3 on the Society of Automobile Executives (SAE) scale is available on American automobiles today and has proven to be very popular amongst consumers. Technology convergence of semi-autonomous vehicle and connected vehicles can bridge the time gap until mass adoption of autonomous vehicle and contribute to reducing annual traffic fatalities. Combining these technologies will give drivers additional safety features thus providing them with the opportunity of making better decisions.
INDUSTRY ANALYSIS: AN EXAMINATION OF AUTONOMOUS VEHICLE TECHNOLOGY

Tagline

Autonomous Vehicle (A/V) technology has been advancing at a rapid pace but the prospect of mass deployment has not been achieved. Inherent expected benefits of this technology such as reduced loss of life, productivity improvements, and greater vehicle efficiency utilization have yet to materialize. The American public’s resistance, and governmental regulation have prevented widespread adoption of this technology that while developed and continuously evolving, is still in its testing phase. Public concerns regarding safety are justified as highly publicized (Lohrmann, 2018) failures of the technology have been reported, heightening public concerns.

Keywords

A/V technology, Driverless, Lidar, Cloud-based computing, Artificial Intelligence, Radar, Mapping, Self-driving, Robotic, Data Analytics, Connected Vehicles (CV’s), Smart Cities, DSRC, C-V2X, ADAS

Executive Summary

Autonomous Vehicle technology has developed over time and this article will explore the origins of the technology and follow the progress of this rapidly advancing technology till present day. Autonomous Vehicle technology consists of six levels which was created by the Society of Automotive Engineers in 2014, and subsequently adopted by the National Highway Traffic Safety Administration. Commencing with Level Zero, it consists of no automation as the driver completes all of the driving tasks. Level One Thru Level Five (Fig. 1) consist of ever increasing levels of autonomy where Level Five is complete autonomy requiring no intervention from the driver.

Numerous companies have received government approval for testing and trials not only throughout the United States but world-wide. The scope of this article is concerned with development of this technology within the United States, and will be the area of focus. This article will explore the variety of technologies utilized such as AI, Machine Learning, radar, LIDAR, laser light, GPS, Odometry, telemetry, sensor fusion, Deep Neural Networks, IMU’s and computer vision. Prominent players within the industry are utilizing a variety of technology platforms with no industry technology standard, instead utilizing a free-style mix of different technology components. This article will endeavor to explore the divergent technology platforms each of the prominent players have adopted, and compare and contrast.
With the rapid advances in Autonomous Vehicle technology, automobile manufacturers have provided consumers optional products with increasing levels of autonomy rolling out such features as adaptive cruise control, parking assistance, lane keeping assistance, and automatic emergency breaking. These features have introduced American drivers to the lower levels of autonomous vehicle technology providing added safety benefits. The bifurcation of Autonomous Vehicles and Connected Vehicles (vehicle to infrastructure- V2I, Vehicle to Pedestrian-V2P and Vehicle to Vehicle- V2V) will be explored as there does not exist a melding of these two types of technology platforms that are currently being tested. These two separate stand-alone technologies are in their beta phase.
INDUSTRY ANALYSIS: AN EXAMINATION OF AUTONOMOUS VEHICLE TECHNOLOGY

Introduction

In May 2016, the first US death involving a semi-autonomous vehicle was reported (Vlasic & Boudette, 2016). The Tesla Model S, while being operated in autopilot mode failed to detect a white 18-wheeler crossing the highway in the bright sunshine. The Model S crashed under the trailer at full speed killing the driver. While over 100 traffic fatalities occur each day in the United States (Bomey 2018), this accident was not supposed to happen with an autonomous vehicle. Widely reported nationally, a second sensational accident occurred in Tempe, Arizona earlier this year with a Waymo Autonomous Vehicle killing a pedestrian (Wakabayashi 2018). According to a preliminary report released by the National Transportation Safety Board (NTSB). Uber did not have emergency braking enabled on the vehicle so as to prevent erratic behavior (Laris 2018). It is no wonder that in a recent automotive study (PR Newswire 2018), American drivers believed roads would be safer if all vehicles were fully autonomous dropped from 63% in 2016 to 49% in 2018. Two years ago, Cox automotive study showed 30% of respondents stated they would never own an autonomous vehicle. In the 2018 study that figure increased to 49%. Karl Brauer, executive publisher of Autotrader and Kelley Blue Book stated, “As awareness around the development of autonomous technology increases, we’re seeing some dramatic shifts in consumer sentiment” (PR Newswire 2018).

Autonomous Vehicles not only have technological hurdles still to overcome, but public acceptance is declining and apprehension increasing. The benefits of this technology are expected to reduce traffic fatalities by 90% (McKinsey & Co. 2015), as well as prevent $190 billion in damages. A market research study (Allied Market Research 2018) predicts Autonomous Vehicle car market will be worth $57 billion in 2019, and expected to grow to $557 billion worldwide by 2026 representing a ten-fold increase. The stakes are extremely high with such significant sums of capital and human lives at stake. Autonomous Vehicles are coming albeit slowly as the lower levels of automation have been embraced by consumers. Levels 1-3 which offer consumers driver assistance, partial automation, and conditional automation will comprise the bulk of the expected Autonomous Vehicle car market in 2019 according to the Allied Market Research study.

Autonomous Vehicles represent a technological leap forward that can influence how individuals view mobility (Howard and Dai 2014). The disruptive aspects of new technology cannot be underestimated. Expected shifts in business models, insurance, land use, safety and security may very well contribute to disruptive effects. Numerous companies have invested billions in this technology as they test their proprietary technology platforms in the pursuit of a breakthrough that will be widely accepted and deployed. Clayton Christensen (2011) postulates that disruptive innovation causes great firms to fail, but they do so unwillingly. If this industry fails to convince consumers of the efficacy and safety of fully (Level 5) autonomous vehicles, it may very well lead to the demise of the companies that fail to deliver.
The Industry

The Autonomous Vehicle technology environment has progressed tremendously in the last few years with numerous competing industries vying for the pre-eminent technology platform. Worldwide competition has been keen, but this article will explore Autonomous Vehicle technology within the United States. Beginning with a history of Autonomous Vehicle technology and a review of the progress, the article will then pivot towards the analysis of the key technology platforms of the major players within the industry. Unlike the automobile industry where that market is dominated by the automotive manufacturers themselves, the Autonomous Vehicle “industry” not only includes automotive manufacturers, but technology companies, software companies, search engine companies, and book sellers. With an emphasis of the specific technology platforms and the benefits, features, and drawbacks of each of the technologies this article will endeavor to review the perceived benefits of each.

Connected Vehicles and Smart Cities also play a crucial role in the overall aspect of Autonomous Vehicles. However, at this point they remain separate and distinct from Autonomous Vehicles technology. This is somewhat surprising given that connected vehicles appear to be closer to mass deployment on a much earlier timeline than Level 5 Autonomous Vehicles (Fig. 1). Connected Vehicles send and receive information from their environment through a variety of sensors providing drivers with real time information so better and safer traffic decisions can be made.

Fig. 1- Society of Automobile Engineers, Levels of Automation 2014(Adopted by DOT)
Stakeholders

The stakeholders within the Autonomous Vehicle industry run the gamut from automobile manufacturers looking to continue their domination of the industry they created to software and hardware technology companies. Software companies play a major role in tying all of the divergent technologies together and forcing cohesion while still utilizing automobile platforms. Major player in the U.S. Autonomous Vehicle technology sector include Tesla, Waymo, GM, Ford, Voyage, Toyota, Ford, Uber, and Lyft.
The media plays an important role in this industry providing information to interested parties about the latest advances, deployments and failures. They closely watch this industry quick to exploit and highlight failures communicating this information to a thirsty public eager for any tidbits of information about this new technology.
Lastly, the most important stakeholder is the general public. They are the ultimate customers of Autonomous Vehicle Technology and will be utilizing the product. With the expected benefits in terms of modification of business models, land use, safety, security, and productivity improvements an eager public awaits the continued testing and improvements to the technology.

Method

An Industry Analysis of the Autonomous Vehicle technology will be the first in a series of three articles in the fulfillment of the requirements for the DBA degree at the Muma College of Business at the University of South Florida. The second article will present and review interviews conducted with industry thought leaders. Their views on the expected and perceived benefits to American society will be explored and compared. Interviewee will include experts from Government, Academia, Media, and Autonomous Vehicle industry. The third and final article will synthesize all of the information contained within the first two articles and highlight the gaps and summarize the conclusions of the industry thought leaders on the expected changes and benefits of Autonomous Vehicle technology.
The Autonomous Vehicle technology industry is undergoing rapid advancements and these developments have taken place within the past few years. While no “industry technology standard” exists numerous companies are competing to develop fully autonomous vehicles with their own proprietary solutions to the complex technology. Primary sources of information on this industry include numerous articles, peer reviewed journals, books, news reports, Autonomous Vehicle conferences as well as information supplied by many of the companies involved in the development of this technology. A literature review of the industry revealed gaps which included the types of technology platforms utilized. It appears there are two primary tracks of development within the industry, autonomous vehicles, and connected vehicles.

Background

In general, all autonomous vehicles have technology that read its surroundings. This technology differs with manufacturers, but all vehicles utilize sensors, camera, and some type of radar and/or LIDAR. Terms such as GPS (Global Positioning System), Lidar (survey method of distance measurement using pulsed laser light), software, Radar (object detecting system utilizing radio waves), Sensors (devices utilized to detect environmental change and send findings to other devices) are used when describing the technology contained within A/V’s.
Software coordinates all of these disparate parts in the form of Artificial Intelligence and Machine Learning. NVIDIA and CAGR are considered the datacenters of Autonomous Vehicles and are utilized by the major players in the Autonomous Vehicle technology field such as Tesla, Google, Delphi, and Intel.

Other terms such as V2V (Vehicle to Vehicle), V2P (Vehicle to Pedestrian) and V2I (Vehicle to Infrastructure) are used frequently as well in the context of connected vehicles. These three terms refer to direct communication between A/V’s as well as direct communication with other devices sharing telemetry data. Connected Vehicles receive their information from other vehicles as well as infrastructure which means Smart Cities, IE- areas outfitted with sensors that provide traffic conditions and safety information directly to vehicles and pedestrians. Technology contained within connected vehicles include a short range radio, antennas, and a rear-view mirror specially modified that provides the driver updated information on traffic conditions.

Crash reduction rates of Connected Vehicles and Driver Assist technologies are expected to be between 15%-70% according to an analysis of crash data from 2005-2008 (Yue & Abdel-Aty 2018). Combined with Active Traffic Management these strategies could further safety and efficiencies.

In 2016, the U.S. Department of Transportation (USDOT) awarded New York City, Tampa, Florida and Wyoming $45 million to create a Connected Vehicle (CV) Pilot Deployment Program (Fig 4- CV Pilot Tampa). Sponsored by the USDOT Intelligent Transportation Systems Joint Program Office (ITS JPO), the CV Pilot Deployment Program is a federal effort to deploy cutting edge mobile technologies nationally in an effort to improve driver safety.

The Federal government has provided additional assistance to the Autonomous Vehicle technology industry by designating ten Autonomous Vehicle (Fig. 2- U.S. Department of Transportation) proving grounds on January 25, 2017. The concept behind the proving grounds is to assist in the testing and development of autonomous vehicle technology using big data and complying with federal regulations. Out of 60 applicants, the following locations were selected:
Table 1- Listing of Autonomous Vehicle Proving Ground Designees

<table>
<thead>
<tr>
<th>Designee</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>City of Pittsburgh and the Thomas D. Larson Pennsylvania Transportation Institute</td>
</tr>
<tr>
<td>2.</td>
<td>Texas AV Proving Grounds Partnership</td>
</tr>
<tr>
<td>3.</td>
<td>U.S. Army Aberdeen Test Center</td>
</tr>
<tr>
<td>4.</td>
<td>American Center for Mobility (ACM) at Willow Run</td>
</tr>
<tr>
<td>5.</td>
<td>Contra Costa Transportation Authority (CCTA) &amp; GoMentum Station</td>
</tr>
<tr>
<td>6.</td>
<td>San Diego Association of Governments</td>
</tr>
<tr>
<td>7.</td>
<td>Iowa City Area Development Group</td>
</tr>
<tr>
<td>8.</td>
<td>University of Wisconsin-Madison</td>
</tr>
<tr>
<td>9.</td>
<td>Central Florida Automated Vehicle Partners</td>
</tr>
<tr>
<td>10.</td>
<td>North Carolina Turnpike Authority</td>
</tr>
</tbody>
</table>
History of Autonomous Vehicle Technology

One could argue that the horse was the first autonomous vehicle. But for the purposes of this paper man-made inventions are the qualifying characteristic for inclusion on the list. The accompanying table (Table 2) and graphic (Fig-5) illustrates some important milestones in the evolution of autonomous vehicle technology:
<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1478</td>
<td>In 1478 the Italian inventor, Leonardo DaVinci sketched a pre-programmed clockwork cart. The invention was powered by coiled clockwork springs and was capable of propelling the vehicle over 130 feet. Had it been built it would have been capable of tackling a predetermined course.</td>
</tr>
<tr>
<td>1868</td>
<td>In 1868 Robert Whitehead was credited with developing the self-propelled torpedo containing rudimentary guidance systems that allowed it to maintain a constant course and depth.</td>
</tr>
<tr>
<td>1933</td>
<td>Sperry Gyroscope Co. invented autopilot systems for long-range aircraft. Called Mechanical Mike, gyroscopes were an integral part of the system and remain so in today’s technology.</td>
</tr>
<tr>
<td>1945</td>
<td>Ralph Teetor did not like how his attorney drove, so he invented cruise control in 1945 to combat poor driving from his attorney. His invention smoothed out automobile rides and became commercialized in 1958.</td>
</tr>
<tr>
<td>1961</td>
<td>At the height of the space race scientists pondered how autonomous vehicles would operate on the moon. Called The Cart, James Adams a Stanford engineering student came up with the idea for a remote controlled lunar rover. Outfitted with cameras then, they still play a pivotal role in today’s autonomous vehicle technology.</td>
</tr>
<tr>
<td>1977</td>
<td>Tsukuba Mechanical, a Japanese company developed an A/V passenger vehicle that was capable of traveling 20 miles per hour, and could identify street markings with its two cameras.</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>1987</td>
<td>After 8 years of development, Ernst Dickmann’s VaMors (German language acronym) Mercedes Van was introduced. Computers controlled the gas pedal, braking, cameras and steering. Computers controlled the cameras which could move, thus providing greater visibility. The van was completely autonomous, and achieved speeds of 97 kilometers per hour on an empty autobahn.</td>
</tr>
<tr>
<td>1995</td>
<td>General Dynamics created the MQ-1 Predator drone in 1995, another type of autonomous vehicles. The drone contained technologies being adapted for cars such as radar and thermal imaging cameras.</td>
</tr>
<tr>
<td>2004-13</td>
<td>U.S. Department of Defense, DARPA division challenged inventors of autonomous vehicle technology by offering prize money for vehicles to self-navigate a 150-mile desert trip. Although no entrants won the challenge, subsequent challenges in later years produced entrants that completed the course.</td>
</tr>
<tr>
<td>2015</td>
<td>In 2015, Tesla introduced Autopilot which was an advanced driver-assistance program capable of handling lane centering, adaptive cruise control, change lanes without driver assistance, self-parking, and car summoning. This feature was delivered to Tesla Model S owners by way of a software update.</td>
</tr>
<tr>
<td>2015</td>
<td>University of Michigan launched MCity, a testing facility for autonomous vehicle technology utilized by Ford Motor Company.</td>
</tr>
</tbody>
</table>
Fig. 5- History of Autonomous Vehicle Technology (http://www.wired.com/brandlab/2016/03/A-brief-history-of-autonomous-vehicle-technology/)

**Tesla**

Tesla is an automotive and energy company best known for its electric automobiles. Tesla has been a leading company in the development of autonomous vehicles having delivered its autopilot program to its Model S customers via a software update. Autopilot is an advanced driver-assistance system providing Level 3 automation to its owners. Tesla has now provided Enhanced Autopilot, which is the second release of its software product. Tesla’s technology platform does not include Lidar. Often referred to as computers than can drive, Tesla models (Model 3, Model S, Model X) are electric vehicles with enhanced software (Artificial Intelligence) where computers can do all of the work through the Vehicle Management System. Tesla announced they had overcome production issues with their new Model 3 IN Q3 of 2018, claiming they outsold Mercedes Benz in the U.S. The FBI announced shortly thereafter they would investigate Tesla production claims.
Waymo

Waymo is Alphabet’s (Google) autonomous vehicle subsidiary. Waymo utilizes Chrysler Pacifica vans outfitted with their own proprietary technology platform developed in conjunction with their software and technology partners. With over 10,000,000 self-driven miles and six billion in simulation they have the most experience in the A/V industry. Their Artificial intelligence (AI), and machine learning (ML) have been enhanced with all of the actual and simulation driving enabling their vehicles to navigate through many hazards, as every vehicle in their fleet shares its information with the rest of the fleet. With over 400 vehicles in use in Chandler, Arizona they have launched the first autonomous vehicles taxis in the area. Thus far, Waymo has filed 338 patents between 2010 and July 2017 for autonomous vehicle technology. According to a UBS Warburg report, UBS cites that Waymo may deliver $114 billion in revenue by 2030, delivering a bigger impact on Alphabet’s stock than YouTube or cloud computing (Krause 2018). Waymo sued Uber in 2017 for stealing self-driving sensor designs. In early 2018, they settled the lawsuit and Waymo received $245 million in Uber stock. Waymo is ordering 62,000 Chrysler Pacifica’ hybrids as well as 20,000 ($1.4 billion) Jaguar Land Rover I-Pace electric vehicles (Higgins 2018). Expected delivery of the I-Pace is in 2020 to 2022.

Voyage

Voyage is a self-driving taxi company deploying their fleet into geo-fenced communities. Residents use an app to summon the vehicle and it takes them to their destination. Voyage has deployed their service to the Villages in California, and the Villages in Florida. These communities are both self-contained retirement communities with downtowns and shopping stores, and represent ideal testing laboratories for the technology. Voyage is not charging customers for this service as of late. Voyage’s first autonomous vehicle, affectionately referred to as “Homer” contained Velodyne’s HDL-64E LIDAR. Its first deployed taxi, the G1 was a Ford Focus costing approximately $250,000 all in. The G2, which is their second generation vehicle is based upon the Chrysler Pacifica hybrid and cost is approximately $200,000. It utilizes Voyage’s own autonomous vehicle technology as well as Velodyne VLS-128 LIDAR a significant improvement over the LIDAR in Homer. The new vehicle employs improved sensors and best in class safety systems. Teaming up with Enterprise, Voyage will not own their vehicles, but will instead leverage the strength of Enterprise’s fleet management and maintenance program, and lease the vehicles from Enterprise.

GM

GM’s approaching to Autonomous Vehicle Technology is multi-faceted. Level 2 technology is available on their Cadillac line, and they are working diligently on fully autonomous or L5 technology on vehicles through the Cruise Holdings division. GM’s Cadillac CTS 2018 model has some of the most advanced autonomous vehicle technology available to consumers today. The Level 2 “Super Cruise (Also has some Level 3 functionality) is available on their 2018 Cadillac CT6 that allows hands-free driving on highways. Super cruise is limited to divided highways and is positioned for individuals who drive long distance long commutes.
The system will automatically prompt the driver to return to control during periods of congestion or when conditions warrant and will alert the driver to resume control.

According to GM CEO and Chairman, Mary T. Barra, “We have the ambition, the talent and the technology to create a world with zero crashes, zero emissions and zero congestion.” It’s not only their slogan, it’s their mission. With bold statements such as that GM is putting its money where its mouth is. In 2016 they purchased Cruise Automation for upwards of $1 billion, creating a new division, GM Cruise Holdings. Cruise Automation was known for creating an after-market kit for consumers to convert certain cars (Audi A4 and S4 models) into autonomous vehicles. This technology has now been integrated into the new divisions vehicles. GM invested another $1.1 billion into the company along with Softbank which invested $2.25 billion. Both Softbank and GM have stakes in Lyft as well. GM invested $550 million in Lyft 2016. Although Lyft recently inked a deal with Waymo, GM’s deal with them is not exclusive. Chevrolet Bolts were the first Cruise AV’s and use two Lidar sensors mounted on the roof. Thus far GM has built 180 Cruise AV’s which are second generation and include a bigger suite of sensors. These vehicles are being tested by employees in the San Francisco area. GM already owns a ride-sharing company, Maven and is utilizing its own app- Cruise Anywhere with its San Francisco employees and the Cruise A/V’s.

With a massive cash infusion, GM has the resources to continue testing A/V technology and has the partnerships to monetize their technology in ride sharing services. They are also expert in mass production of vehicles, something that Tesla has still not completely mastered. In March of 2018, GM announced they would begin mass production of the Cruise A/V in 2019 describing it as “the first production ready vehicle built from the start to operate safely on its own, with no driver, steering wheel, pedals, or manual controls.” The vehicle will contain 5 LIDAR units, 21 sensors, 16 video cameras, three interior touch-screens and will interact with passengers via a phone app. GM will require an exemption from existing Federal law in order to field it’s A/V fleet.

**Ford**

In 2017, Ford purchased Argo AI for $1 billion in order to jump start its autonomous vehicle technology portfolio. While not the most advanced in A/V technology, Ford is playing the long game when it comes to the deployment of these vehicles. Ford’s safe best is exemplified in Argo AI CEO Bryan Salesky who posits “Those who think fully self-driving vehicles will be ubiquitous on city street month from now or even in a few years are not well connected to the state of the art or committed to the safe deployment of the technology.” Ford’s commitment is real having pledged another $3 billion investment (through 2023) in its newly formed A/V subsidiary, Ford Autonomous Vehicles LLC. This new division will include self-driving systems integration, A/V research, advanced engineering/ A/V transportation as a service network development. These operations are moving away from headquarters and will also accept outside investment. Given the state of the industry it would not be surprising for Ford to announce new partnerships with the new division in the future and follow in the footsteps of the industry.
Ford has committed to bringing a fully Autonomous Vehicle to market by 2021. In addition to the Argo AI purchase, Ford has also invested in Velodyne given their track record in the development of their LIDAR technology. Ford purchased an Israeli company SAIPS, an AI company focused on Deep Learning, and have licensed Nirenberg Neuroscience LLC technology that provides system vision task like navigation, collision avoidance, object and facial recognition. Lastly, Ford has invested in a Berkeley California company that produces 3D mapping abilities.

Ford is dispatching a fleet of A/V test vehicles to Miami, Pittsburgh, Dearborn and Washington DC beginning in 2019 in order to collect data and map the areas.

**Uber & Lyft**

Uber and Lyft are both ride-sharing transportation companies proving mobility by the utilization of a phone app. Uber suffered a number of devastating setbacks earlier this year. One of its autonomous vehicles (Volvo XC90) was involved in a deadly pedestrian fatality when it failed to stop. It was the first known pedestrian fatality involving an Autonomous Vehicle and Uber halted the testing of its vehicles after the accident on public roads in Phoenix, San Francisco, Pittsburgh and Toronto. The National Highway Traffic Safety Administration opened up an investigation into the crash, and preliminary results from the investigation indicated that the emergency breaking feature on the vehicle was disabled. Uber also settled a lawsuit with Waymo earlier this year that cost them $242 million in equity.

Uber created its own separate Autonomous Vehicle subsidiary, Uber Advance Technology Group based in Pittsburgh, Pa. The division is responsible for research and testing of its Autonomous Vehicles. Despite these setbacks, they continue to move forward and have announced that Autonomous Vehicle technology is in their future and are in talks with Toyota to possible partner or license their technology. Uber is scheduled to launch their IPO in 2019 so these setbacks do not bode well.

Lyft is also scheduled for an IPO in 2019 but have had more success than Uber this year. They purchased Blue Vision Labs, a London based start-up that uses smartphone cameras to develop imagery in augmented reality layers. Lyft, which received a major cash investment from General Motors is collaborating and partnering with Waymo, as well as Magma, a Canadian Auto parts manufacturer. The first cars from Lyft’s Level 5 Autonomous Vehicles will be Ford Fusions equipped with Lyft’s own technology. In May, Lyft announced they were partnering with Aptiv and launching 30 ride-hailing autonomous vehicles in Las Vegas. The vehicles will be using Aptiv technology platform on the Lyft network. Lyft’s corporate strategy appears to be providing forward motion as the collection of its partners and collaborators continues to expand.

**Laws & Liability**

Currently, individual states establish their own rules regarding the operation of autonomous vehicles. The federal government has taken a relatively agnostic view of legal and regulatory involvement when it comes to autonomous vehicles regulations and instead has been encouraging these companies to develop the technology and providing guidance through the
Department of Transportation. Since 2012 each year more and more states have considered enacting Autonomous Vehicle legislation. Thus far twenty-nine states (National Conference of State Legislatures 2018) have passed laws related to Autonomous Vehicles. Governors in another 10 states have issued executive orders enacting regulations referencing Autonomous Vehicles.

Liability laws which already exist, have been tried and tested for decades in the courts. Product liability precedence has been established and product liability laws are already in place and should be sufficient to handle the modification and changes coming to the automotive industry. Until full automation, the thicket will be how to determine proportional responsibility in autonomous vehicle accidents that are partial, and not fully autonomous where the driver and the technology are at fault.

The on-demand mobility business model planned by many of the industry stakeholders for full L5 automation may very well reduce individual ownership of vehicles as customers will summon transportation on their phone apps. The courts have thus far been successful in handling technical issues brought before them, and the expectation is they are positioned to handle them in the future. That doesn’t mean that there will not be challenges ahead, or that specific fact patterns will be the same. History shows that the courts have evolved, and been able to handle extremely technical issues brought before them.

Safety

Automobile safety technology has advanced greatly since the first vehicles were introduced. According to the National Highway Safety Administration, there are five Eras of safety:

Table 3- Five Eras of Safety

<table>
<thead>
<tr>
<th>Era of Safety</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1950-2000 Safety/Convenience Features- Cruise Control, Seat belts, Anti-lock brakes</td>
</tr>
<tr>
<td>Second</td>
<td>2000-2010 Advanced Safety Features- Electronic Stability Control, Blind spot Detection, Forward Collision Warning, Lane Departure Warning</td>
</tr>
<tr>
<td>Fifth</td>
<td>2025- Fully Automated Safety Features- Highway Autopilot</td>
</tr>
</tbody>
</table>
NHTSA study indicated that in 2010 vehicle crashes cost $242 billion in economic activity, $57.6 billion in lost worker productivity, and $594 billion due to loss of life and reduction in quality of life due to injuries sustained in traffic accidents. These costs have gone up every year as the number of accidents and traffic fatalities has been increasing. Last year there 1.4 million traffic fatalities worldwide (Naughton 2018) and US fatalities increased 14% from 2014-2016 (Naughton 2018). US traffic fatalities for 2017 were 40,100. The earlier Autonomous Vehicle and Connected Vehicle technology can be delivered to the market on a mass adoption basis, the sooner these statistics can begin to decline.

Currently there are 55 companies permitted in California to test A/V. California state government requires each of these companies to file safety and accident reports. From 2014 through August 2018 there have been 54 accidents reported on California roads (Kokalitcheva 2018) involving self-driving cars. The interesting statistic here is most of these incidents occurred when a human driver bumped into or rear-ended the A/V. A/V technology was blamed in four of the incidents, and only one incident involved a vehicle in full autonomous mode. Safety is the primary concern for passengers in A/V and the industry has not done a good job allaying the fear of the general public. Statistics point out the opposite as they are much safer that human drivers, but perception is driving these fears not fact. The two fatal accidents involving partially autonomous vehicles in March have stoked the fears of the technology and have overshadowed the technological advancements registered with the companies testing the technology. Waymo recently recorded its 10 millionth mile self-driven milestone and every foot of their experience is recorded and analyzed by AI and machine learning so any incidents and all experiences can be analyzed. Reaction and responses can be catalogued and shared with all their other vehicles enhancing road safety. They self-report that an incident occurs once every 50,000 miles which is an enviable statistic that human drivers can only dream of achieving.

Morning Consult released a survey in January of 2018 surveying over 2,000 adults on their thoughts and perceptions of Autonomous Vehicles. Fifty-eight (58%) of respondents don’t trust A/V’s right now, but as technology evolves they could trust them (Ramlet 2018). This statistic was reported prior to the widely publicized Autonomous Vehicle accidents resulting in death. An information gap about Autonomous Vehicle technology also exists as “60% of Americans know little to nothing about autonomous vehicles”. (Ramlet 2018)

Cybersecurity

Blockchain technology may be coming to autonomous vehicles in the near future. According to Frost & Sullivan, a market research firm, "By 2025, 10–15% of the entire CV industry transactions are expected to be on Blockchain; which will push OEMs and suppliers to invest actively in the Blockchain infrastructure in partnership with tech consortiums, financial institutions, and regulatory establishments" (Gadam 2018). That certainly can address concerns for the safety of transactions, but what about the actual Autonomous Vehicle technology and susceptibility to hackers, and bad actors?

With advanced technology containing millions of lines of code, in conjunction with vehicle to everything communication the vulnerability of these systems to hacking increases exponentially. Safety concerns are already of paramount importance and technology safety is even more imperative. Cyber security, just like safety impacts public perception regarding trust
and acceptance of Autonomous Vehicles. Recently a Tesla Model X and a Jeep Cherokee were hacked with the result of vital vehicle functions controlled outside of the vehicle (Jaisinghani 2015). Chrysler-Fiat recalled over 1.4 cars as a result of the hack, and Tesla repaired the breach within two weeks of being alerted.

While these incidents are isolated they represent the vulnerabilities of the vehicles and more must be done to strengthen the vehicles from potential hackers, or even deliberately providing false data. Blockchain utilizes cryptography and advanced algorithms so that all data can be verified and checked in real time. Blockchain, which is usually discussed when the subject of cryptocurrencies is broached may provide the technological answer to the cyber security of autonomous vehicles.

**Terminology**

Some of the most critical definitions for key terms in Autonomous Vehicle technology.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidar</td>
<td>Surveying method that measures distance utilizing pulses of laser light and quantifying the reflected pulses with a sensor.</td>
</tr>
<tr>
<td>Radar</td>
<td>Surveillance utilized for detecting objects and their distance by projecting high frequency electromagnetic waves to the object bouncing off back to the source.</td>
</tr>
<tr>
<td>Odometry</td>
<td>Motion sensors generate data to determine its current position from a starting point.</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System owned by U.S. government is a satellite navigation system constantly sending out radio wave signals to Earth received by users and given precise location coordinates.</td>
</tr>
<tr>
<td>Smart Cities</td>
<td>An urban area that utilizes sensors to receive and transmit data to more effectively utilize assets and resources in order to optimize traffic and safety.</td>
</tr>
<tr>
<td>Sensors</td>
<td>A device which is designed to collect data from its environment and transmit that data.</td>
</tr>
<tr>
<td>C-V2X</td>
<td>Acronym for cellular vehicle-to-everything. Next generation technology utilized by mobile phones and devices utilizing 5.9 GHz ITS spectrum. Builds upon DSRC.</td>
</tr>
</tbody>
</table>
Geo-fenced

Virtual boundary around an actual physical area.

Discussion

Reviewing the information gathered from the industry analysis we can see two areas of technology focus. The first area is on the autonomous vehicle technology. The second area is on the connected vehicle. These are two separate and distinct technology platforms. No convergence exists with these two technologies as of late as each side is continuing to develop, test, and perfect. This bifurcation of two different technologies and lack of convergence prevents the autonomous vehicle from containing the best of both worlds in combining the technologies available and providing the public the safest possible product. This bifurcation may be detrimental to the overall safety of the Autonomous Vehicle technology industry as we have seen a reduction in the polling numbers of the American people in the acceptance of Level 5 automation. Morning Consult conducted two polls earlier this year (Ramlet 2018), one before the two fatal autonomous vehicle accidents and one just after. Respondents perceptions of Autonomous Vehicles being less safe than human drivers rose from 36% in the January survey to 50% in the April survey.

In order to overcome these objects, safety is of paramount importance. While the statistics of safety and driving show Autonomous Vehicle technology to be safer than human driving in order to develop a more accepting environment this technology must be experienced and shared with the general public. Perceptions are one thing, but when passengers ride in these vehicles their perceptions change. Sensational crashes do not assist in the reduction of acceptance of fully autonomous vehicles. If the industry wants to realize the enormous economic potential of this technology not only must it be safe, but perceptions will have to match reality.

Conclusions

We are at a tipping point with autonomous vehicle technology as the players are beginning to hunker down with their differing technology platforms and have begun to identify, pursue, and conclude deals with manufacturers, software and hardware providers, ride sharing companies, data and bandwidth companies, car rental companies so that they may position themselves within the industry to sweep up market share one the technology has developed to the point of coalescing around a business model that is practical, safe, and makes economic sense. These companies recognize the enormous revenue potential as well as expense in technology testing. Many companies have no desire to be “blockbustered”, which is ignoring the competition to the detriment of their own business. This verb was created by the author to describe the process of an existing business too arrogant and stale in its management to recognize an upstart disruptor that will eventually destroy the business.

Level 5 Autonomous Vehicles still require technological breakthroughs that will take additional time. Connected vehicle technology must be combined with Level 2 and Level 3 Autonomous Vehicles now so that we can take advantage of the inherent safety benefits to prevent traffic fatalities from both technology platforms. Embracing and rolling out this technology will highlight improvements in safety that would be embraced by the general public. We must walk
first with the lower levels of A/V technology and combine with connected vehicle technology which includes V2V, V2P and V2X.

Fatal accidents damage the “trust” factor of the general public with this new technology despite the facts from the actual safety records. How does the industry overcome the effects of these false perceptions? These perceptions while valid in the reflection of the opinion of the survey respondents, they represent fake news as it relates to the actual facts. Unfortunately, perception trumps facts in this instance. If the Autonomous Vehicle Industry wants mass adoption and the inherent huge market they are going to have to do a better job of convincing Americans of the efficacy of this technology. Overcoming these false perceptions with road shows and demonstrations, continued testing and no more fatal accidents would go a long way in reversing these perceptions. It may even require Autonomous Vehicle technology to perform virtually flawlessly in order to gain widespread acceptance.

Empirical analysis of crash data showed that connected vehicle technology may assist in reducing traffic accidents (Yue & Abdul-Aty 2018). Combining this technology with autonomous vehicle technology in the Level 2 & 3 area may further aid in the reduction of accidents by removing the human element. If pedestrians have this connected vehicle technology as well they can be on alert and receive alerts to better assist in their navigation of our roadways as well. Further study is need to ascertain the full benefits of combining these technology platforms.
INDUSTRY LEADERS SHARE THEIR THOUGHTS ON AUTONOMOUS VEHICLE TECHNOLOGY AND ITS EXPECTED SOCIETAL BENEFITS WITHIN THE UNITED STATES

Tagline

Autonomous Vehicle Technology has made grade strides in the last few years, but widespread adoption has not taken place. Industry though leaders from Academia, Industry, Government and the Media share their views on what the expected and perceived benefits of this technology will bring to American society, as well as mass rollout.

Keywords

A/V technology, Driverless, Lidar, Cloud-based computing, Artificial Intelligence, Radar, Mapping, Self-driving, Robotic, Data Analytics, Connected Vehicles (CV’s), Smart Cities, DSRC, C-V2X, ADAS

Executive Summary

Autonomous Vehicle technology is progressing at a rapid pace as many companies are investing in research to improve the technology. American society has not yet received the expected benefits of the roll out of this technology. An eclectic group of industry experts were sought out to be interviewed to discuss Autonomous Vehicle technology and the perceived and expected benefits this technology will bring to American society. A diverse cross-section of industry thought leaders were interviewed for this article who represented government, academia, media, and industry. Participants ranged from the President of Florida’s only public STEM University to professors involved in technology research to individuals involved in reporting on technology advancements.

During the semi-structured interviews, interviewees responses to open-ended interview questions provided insight of expert opinion on what the expected and perceived benefits to American Society Autonomous Vehicle technology was expected to deliver in terms of productivity, and improvements to daily routines. Respondents indicated mass adoption more than ten years out, but when it happens, expect many societal benefits that will lead to greater productivity and improved living conditions. Increased access and mobility were also cited as benefits to mass adoption as well as improved living conditions, reduced stress in commuting, and more free time. Modification of existing business models was also anticipated, specifically with a decrease in individual automobile ownership. An increase in personal income was anticipated due to the reduction in the depreciating asset model of car ownership, opening up alternative investment and enjoyment pathways of personal income.
INDUSTRY LEADERS SHARE THEIR THOUGHTS ON AUTONOMOUS VEHICLE TECHNOLOGY AND ITS EXPECTED SOCIETAL BENEFITS WITHIN THE UNITED STATES

What impact will autonomous vehicles (AVs) have on society and work life, in particular, as capabilities are incrementally rolled out? What will the rollout look like? When can we expect it to happen? The answers to these questions will have significant impact on how we work and how we live. Unfortunately, nobody can predict the future with certainty. In this research, this question is looked at from the perspective of industry thought leaders. The interviews that were conducted were wide ranging in scope utilizing open ended questions. Interviewees were represented from a variety of backgrounds including a University President, university professors, entrepreneurs, a State Senator, a state agency employee, local news anchor, automotive industry think tank CEO, 3PL logistics company CIO, and a civil engineer. Among the areas examined:

- Expected date of mass adoption of autonomous vehicles
- Expected societal benefits of using this technology
- Productivity improvements
- Daily routines
- Vehicle ownership
- Business model changes
- Problems with A/V technology

Of specific interest was the respondent insights into three key research questions:

RQ1- What is the expected impact Autonomous Vehicle technology will have on productivity in American society?

RQ2- How may daily routines change for Americans with the utilization of Autonomous Vehicle technology?

RQ3- What perceived impact will Autonomous Vehicle technology have on labor productivity?

Some of the more interesting insights from the process included increased mobility & access, trip chaining and automated errands, and a consensus opinion that we are more than ten years away from mass adoption of autonomous vehicle technology at the earliest.

Methodology

The purpose of this research was to determine what industry experts perceive the future benefits of Autonomous Vehicle technology and to garner their opinion of when the expected mass deployment of this technology would happen. Perceptions were also explored on what the expected societal benefits this technology would bring. A total of 11 experts were interviewed. The interviews took place in multiple locations which was dependent upon interviewee schedules. Four interviews were by teleconference, three were held at offices of Florida Polytechnic University, two were held in the interviewees offices, and the last two were held in conference rooms at the interviewees work locations. A prepared list of questions was utilized for each interview (See Appendix for questions). A Sony IC recorder device was used for each interview. Verbal permission to record each interview was obtained from each subject prior to
the commencement of the interview. Upon interview completion interview recordings were electronically sent to on-line website Rev.com where they were contracted with to provide transcripts for each interview. Software was purchased from Nvivo.com so that interview data could be downloaded into the software program and the data could then be coded for thematic relevance, frequency and convergence of thought patterns.

**Interviewee’s**

Requests were made to 25 individuals to volunteer to be interviewed for this article. Due to scheduling conflicts and refusals, a total of eleven individuals agreed to be interviewed. The eleven individuals interviewed for this article possess over 100 years of professional experience, and interviewee ages run the gamut from 31 to 60. Six of the eleven interviewee’s possess PhD’s, 4 have earned their Masters and one interviewee received his Bachelor’s degree. All interviewees have experience within the Autonomous Vehicle technology sector either through their work in the fields of research, industry, media or government. Each interviewee’s biography is included in the Appendix.

**The Interview**

The interviews were semi-structured and conducted either on the phone, in person either in my office at Florida Polytechnic University, other offices within Florida Polytechnic University, at State Senator Jeff Brandes’ office in St. Petersburg, Fl. and at Chuck Henson’s office at Spectrum Bay News Nine in St. Petersburg, Fl. Interviewees were asked a series of questions (Appendix) prepared beforehand, as well as additional follow-up questions that were deemed appropriate due to the discussion that ensued. Some questions, which were on the list, were not asked as some interviewees provided broad answers that actually answered some of the unasked questions. Other questions were asked that were not on the original list as they provided context and additional information necessary as the interview progressed and went into different directions. This researcher made the determination to explore these avenues when they presented themselves. One question which was asked of each interviewee consisted of the following: “If you had to make five sandwiches, could you please discuss your process regarding how you would approach completing the task. While this question has nothing to do with Autonomous Vehicle technology, it was so outside of the realm of the interview that it set each interviewee at ease and brought them outside of the interview. The other purpose of the question was to probe the mindset of the interviewee and to see how they organized and broke down the task.
Q1. When do you think Autonomous Vehicles will be widely utilized?
“We're really early. My feeling is we're at least a decade away, if not more, to solving these problems in a sufficient degree such that you will have initial deployments.”

“I guess it depends on too many factors but probably in ten years. Likely you'll see that widely spread like of people using probably 10 years.”

“*In five to 10 years.*”

Consensus response at 36% (Four respondents) would be within 10 years by 2028. The remaining percentages received one response each for 2025, 2030, 2033, 2035, 2040 and 2060. 54% of respondents indicated that mass deployment would be by 2030 or earlier. This question is of great interest given the expected benefits Autonomous Vehicle technology will bring at the conclusion of the testing phase.

**Mass Adoption of Autonomous Vehicles**

<table>
<thead>
<tr>
<th>Year</th>
<th>Responses</th>
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<tbody>
<tr>
<td>2025</td>
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<tr>
<td>2028</td>
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<tr>
<td>2030</td>
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<td>2033</td>
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<td>2040</td>
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</tr>
<tr>
<td>2060</td>
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</table>

Q2. What types of benefits do you foresee with this technology?
“I think the first interesting one is just going to be providing access to people that don't have access today.”

“I think a lot of benefit, as you know, I think there's certainly a lot of capacity to reduce many deaths, to take driver error out, and particularly now that we are so distracted when we drive. Mobility, I think there's lots of potential there, too.”

Sixty-four percent of respondents indicated that Access & Mobility would be the greatest benefits of Autonomous Vehicle technology. Safety ranked second at 55% of respondents. Additional benefits included traffic management, efficiency, environmental, and land use. With the expected reduction in traffic fatalities with the roll out and mass adoption of this technology
there was concern from one respondent who indicated that organ harvesting would be negatively impacted since the major source of organ donors are victims of traffic fatalities.

**Q3. What types of problems do you think will be encountered with this technology?**

“First is that there are implementations and you see that most of accidents happens that the drivers hit the autonomous vehicles because they don’t understand the culture of the autonomous vehicle.”

“I think the major problems that you'll see will be one, just human interaction with it.”

“We interpret a lot of things when we see somebody crossing the street or we say certain activities. We can look at facial signals, we've facial expressions. Right human language”.

Overwhelming consensus- 63% indicated that the biggest problem with Autonomous Vehicle technology is not the software or the hardware, but human kind. Concerns about human language, human interaction, and human intelligence were all given as major concerns. Overall safety was highlighted when humans interact with A/V. We have been referred to as the unknown element and potentially causing chaos. Given the recent statistics from California regarding the 55 reported accidents involving A/V’s, over 50% were caused by human drivers plowing into the vehicles from all angles. No wonder this is a concern. The obvious concern as Autonomus Vehicle technology is rolled out is the danger posed by human drivers against this technology. The interviewees responses regarding human to human communication-the idea that nonverbal communication hand signals & gestures that are utilized at four way intersections would be reduced, thus possibly contributing to increased safety risk.

**Q4. How will American lives change with Autonomous Vehicle Technology?**

“Well I think the major is the time and probably Americans will get to spend more time with their families because I've heard Americans are the most hard-working.”

“As I said, more comfortable, when you're driving you're going to see more comfort, or let's say less stress, and because you have a lot of assistance with features and other things that increase the safety.”

No consensus with responses to question #4. American lives will change in a variety of ways, among those are mobility, safety, human behavior, and vehicle ownership. Lives will also change by reduced stress for commuting, generational differences in acceptance of A/V technology, and increased family time.

**Q5. Will existing business models change?**

“Well, the entire rental car industry shifts on Uber and Lyft will essentially become platform businesses…”

“We'll see the disruption and everything from regional air traffic to which I think will be much less, because we can drive point to point in a lower amount of time that we could travel via car.”
Prevalent responses to question 5 were quite varied but overriding thematic element here was the auto industry. Vehicle ownership is expected to decrease and automobiles will be part of shared mobility. Concerns about liability, insurance, and lawyers and regional airports were discussed. An interesting response about regional airports concerned their reduced influence as A/V’s could very well interfere with short-haul airline trips disrupting that business model. These reflections should be of concern to regional airport managers looking at future utilization and expansion plans given that this technology might seriously impact how Americans travel in the future.

Q10. How will American’s daily routines change?
“There will be a lot more trip chaining. Okay so trip chaining is essentially multitasking.”

“So since you're in an autonomous vehicle and your essentially not Really in control of the wheel, while you're driving from home to work, you can probably get another set of multiple tasks done while you're sitting in your car and working.”

“There will probably be a lot of empty trips as well, so you can just ask your autonomous vehicle to go to a public's or something and have your groceries delivered or something, so there will be a lot emptier trips”.

Wide dispersion and disparity of opinions to question #10. Trip chaining was discussed, that is sending your vehicle out to run your errands so you don’t have to. If there was a theme with these responses it would be that improvements to human life were on their way. Answers such as quality of life improving, more time to spend with family, life becoming simpler with technology, specifically wearables, and A/V technology and other advancements in technology will help to improve life. Also responses indicated that commuters would arrive at work less stressed as highways are expected to become more efficient with less traffic jams to endure. It was expected that showing up to work less stressed would help employees become more productive at their jobs.

Q11. How do envision American society with mass deployment of Autonomous Vehicles?
“I think it'll just become the norm just like a cell phone is today, to be honest. Right now we're at this cusp of something, of new technology coming out, but it will just be the way, and people will look at me when I say that I used to have a car and I drove my own car.”

The most interesting response from this question was the response that American society would improve because drunk & distracted driving would be a thing of the past. Mobility and less stress were also responses. No consensus or coalescing around one particular issue was evident from interviewee responses.

Q12. Will Autonomous Vehicle technology lead to greater individual productivity?
“I think the vast majority of these things which are related to distracting and drunk driving will obviously go away;”

“The economic impact will I think be the most profound. Because as you know, for an average household in the US, their auto payments and maintenance and all that stuff is the second biggest, if not the first biggest depending on whether they rent or not, expense they have.”
“A lot of time quality of life will most certainly improve.”

Complete consensus on Question 12, totally agreement that A/V technology would lead to greater productivity. Greater productivity is defined as having more personal time to accomplish tasks, commuting time is reduced, commuting time is working, and less lives are lost or injured thus improving productivity. Discussion of the automobile depreciating asset model was discussed. With auto payments being the second largest expense in many households, the reduction in individual automobile ownership could lead to a significant change in individual finances. What will American’s do with this disposable income if not earmarked for auto loan, insurance, and maintenance? Respondents indicated this could be earmarked for retirement, experiential enjoyment, and investment.

Q13. Do you anticipate significant job losses in the economy due to this technology?
“No I don't think so. No."

“I can't. I don't think you can look at automated vehicles, as the cause of mass unemployment. I think it is a symptom of AI. “

“Yes, and no, but I mean like one of the questions I ask is when do we graduate our last class of radiologists? “

“No, I don't. I don't think so. ”

Responses to job losses included yes no and maybe. Some respondents thought there would be major disruptions in the employment market, others thought that while some jobs would go away, they would be more than offset by the new jobs created by this technology. This question has relative importance in that there is great interest in whether or not new technologies cause widespread unemployment and disruption. While the answer to this question from respondents was quite varied, there was really no expectation of a catastrophic employment event. Respondents were all over the map on this question.

Q14. Who do you see as the dominant companies in the Autonomous Vehicle field?
“Well of course we know the Teslas and the Waymo's of the world are at the forefront but I still see Uber and Lyft”,

“Audi, Waymo, Uber, Lyft, and Apple”.

“Those that are leading the pack right now are GM and Mercedes, BMW.”

Corporations expected to dominate the Autonomous Vehicle technology sector include Ford, Tesla, GM, Toyota, Google, Uber, Lyft, Mercedes, Audi, Apple, Voyage and BMW. Hardware companies such as Intel, and NVidia are expected to dominate as well. Voyage, a relatively new player in the industry is expected to play a much bigger role. Investors may very well heed the insight these expects have as they predict who the players in the industry will be.
Discussion

While a minimum of fourteen questions were asked of each interviewee, additional questions were asked to further explore where needed. Interview questions in some instances were similar, such as questions pertaining to daily routine and daily lives change with A/V. In those instances, some answers were combined by the interviewee and there was no need to include every question and answer from each interviewee. Questions were designed as open ended in order to prevent constraining answers from respondents, and allow a free flow of their thoughts, beliefs, and expectations. Formulating open-ended questions instead of simple yes/no format was decided upon in order to get richer data that what is provided with simple yes/no answers.

Coding of the interview data was completed with a manual first pass for recognition of common thematic elements and discovery of any commonality and convergence in interviewee responses. The next level data analysis was completed utilizing Nvivo Pro 12 software. Interview data was downloaded into software program. Each interview was coded creating 26 separate nodes (See Node listing below) which quantified the main themes discovered within the eleven interviews. In some instances, the created node was one of the interview questions. Some nodes were created due to commonality discovered during the first manual pass. Each node had a minimum of one reference in the source material, and 15 nodes had references ranging from 11 to 25. The main purpose of quantifying the qualitative analysis is to create themes from the research that will address the research question (Adu, 2013). The strategy behind the selection of specific coding methodologies is to be consistent with the research question (Saldana, 2013). Finally, additional coding is assigned to the nodes utilizing a “Focus prompt” for the research questions (Kane & Trochim, 2007)

Nvivo Nodes- Developed from Interviews

<table>
<thead>
<tr>
<th>Topic</th>
<th>Files</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will A/v lead to greater productivity</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Who will be the dominant player in A/V</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>What question should I have asked but didn't</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Trucking Industry</td>
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<td>1</td>
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<tr>
<td>Traffic Fatalities</td>
<td>1</td>
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</tr>
<tr>
<td>Technology Convergence</td>
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<td>1</td>
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<tr>
<td>smart cities</td>
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<td>2</td>
</tr>
<tr>
<td>Process for making five sandwiches</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Problems with A/V technology</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>People want experiences, not things</td>
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<td>1</td>
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<tr>
<td>Organ donor Reduction with Fatality reduction</td>
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</tr>
<tr>
<td>New technology frees up money to do other things</td>
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<td>5</td>
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<tr>
<td>Mass adoption of A/V technology</td>
<td>11</td>
<td>18</td>
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<tr>
<td>Lawyers liability</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Land use</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Insurance industry changes</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Individual car ownership decreasing</td>
<td>11</td>
<td>22</td>
</tr>
</tbody>
</table>
Some surprising results in the coding of the interviews included very limited discussion of traffic fatalities, trucking, land use, technology convergence, and smart cities. The trucking industry is suffering a severe labor shortage, and is expected to utilize autonomous vehicles first and resolve the labor shortage (Winick 2018). With traffic fatalities at about 40,000 in the United States annually, it was surprising that this area was not more of a focused response. Technology convergence which would mean the merging of Autonomous Vehicle technology (Level 1-3) with connected vehicle technology, barely registered on the discussion spectrum with the interviewee group. This lack of discussion was also surprising given the benefits of convergence on safety (Mennie 2018 A).

The most significant findings were those nodes that recorded the most references with the interviewees. These nodes included the benefits of A/V technology, how American’s lives will change, and problems with A/V technology. These three areas recorded at least 24 references each from the respondents. These areas generated the most discussion from the respondents.

**Research Question 1** - What is the expected impact Autonomous Vehicle technology will have on productivity in American society?

![Will Autonomous Vehicles lead to Greater Productivity?](image_url)

Fig. 6- Interviewee Responses to “Will A/V lead to greater productivity?”
The expected impact of Autonomous Vehicle technology on American productivity will be dramatic. All interviewees indicated that there would be greater productivity, but focused on different areas. The tree map, and word summary represent query results and follow in Fig. 2 and Fig. 3. Interviewee question tackled the research question by asking if A/V technology will lead to greater productivity. This question was coded as a separate node and a frequency word search query was performed for the top 15 words to ascertain the thematic elements of the answer to the question.

Upon further analysis of the data we can see that there are certain words and phrases that indicate some of the thoughts of the interviewees regarding what type of productivity improvements would be expected. Faster commutes, more productive, less anxiety, more time to do things,

Fig. 7- Tree map of Top fifteen terms “Will A/V lead to greater productivity?”
Research Question 2- How will daily routines change for Americans with the utilization of Autonomous Vehicle technology?

Interviewees responses coalesced around certain words. One interesting phrase was trip chaining. This phenomenon enables individuals to multitask, doing more errands and becoming more efficient by sending out the vehicle by itself to do the errands. Wide disparity in thoughts on how daily routines would change, but provided a representative viewpoint on the different types of changes expected. Interest in this question is due to natural curiosity about how things will change in the future.
Fig. 10- Tree map of the top 10 words query from “How will American’s daily routine change with Autonomous Vehicle Technology?”

Fig. 11- Word summary- Frequency and weighted percentage of Node, “How will American’s daily routine change with Autonomous Vehicle Technology?”
Research Question 3- What perceived impact will A/V technology have on labor productivity?

The question which provided widespread opinions covering the entire spectrum involved the question of anticipating job losses due to A/V technology. Opinion was split on this question as respondents thought there would be losses and increases in jobs as well as major disruptions, but other industries would grow as a result of A/V technology. The accompanying word summary and tree map which show the top 10 words utilized indicate wide divergence of opinion. These answers contrast sharply with unified consensus answers such as top five leaders in A/V technology. (Tesla, Waymo, Ford, Mercedes, and BMW).
Fig. 13- Tree Map- Top 10 words “Do you anticipate job losses due to A/V technology?”

<table>
<thead>
<tr>
<th>Word</th>
<th>Length</th>
<th>Count</th>
<th>Weighted Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>education</td>
<td>9</td>
<td>6</td>
<td>1.68</td>
</tr>
<tr>
<td>drivers</td>
<td>7</td>
<td>5</td>
<td>1.40</td>
</tr>
<tr>
<td>manufacturing</td>
<td>13</td>
<td>4</td>
<td>1.12</td>
</tr>
<tr>
<td>social</td>
<td>6</td>
<td>4</td>
<td>1.12</td>
</tr>
<tr>
<td>economy</td>
<td>7</td>
<td>3</td>
<td>0.84</td>
</tr>
<tr>
<td>employment</td>
<td>10</td>
<td>3</td>
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</tr>
<tr>
<td>maintenance</td>
<td>11</td>
<td>3</td>
<td>0.84</td>
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<td>workforce</td>
<td>9</td>
<td>3</td>
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<tr>
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<td>5</td>
<td>2</td>
<td>0.56</td>
</tr>
<tr>
<td>computer</td>
<td>8</td>
<td>2</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Fig, 14- Word summary- Frequency and weighted percentage of Node, “Do you anticipate job losses due to A/V technology?”
Conclusion

Exciting and interesting changes are in store for American society once mass adoption occurs with Autonomous Vehicle technology. Fundamental shifts in the daily routine are anticipated as life becomes less stressful for commuting and A/V technology improves our lives by being able to trip chain and auto-shop leaving us with more time to enjoy our families. Benefits from A/V technology lead to productivity improvements offering increased mobility and access to transportation as well as a more efficient use of highways. The future looks bright for all of the improvements A/V’s are expected to bring, but not for at least ten years, at the earliest.
CONNECTED & SEMI-AUTONOMOUS VEHICLES CAN SAVE LIVES NOW!

Tagline

Autonomous Vehicles mass adoption is not expected until the 2030’s. Almost 40,000 Americans lose their lives in traffic fatalities every year. The technology for Connected Vehicles and Semi-Autonomous Vehicles is here and ready to be implemented. Why hasn’t this happened yet?

Keywords

Connected Vehicles (CV’s), Semi-Autonomous vehicles, Autonomous Vehicles technology, Smart Cities, DSRC

Executive Summary

The state of California Department of Motor Vehicles has issued 60 permits to companies testing Autonomous Vehicles in the state as of October 2018 (California Dept. of MV 2018). Billions of dollars are being invested by Waymo, GM, Tesla, Voyage, Ford, Mercedes, BMW, and Audi in the pursuit of the technology that will enable these companies to commercialize their products. While the investments are in the billions, it is estimated the A/V market will exceed 500 billion within ten years (Mennie 2018 A). Depending upon who wins the race to bring the best AV product to market existing companies may not survive this technology catfight. However, mass adoption of this technology is years away (Mennie 2018 B).

Meanwhile as this emerging technology is in the testing phase, Levels 1-3 of autonomous vehicles are in operation on our roads today. These autonomous features which include driver assist, emergency braking, highway driving, lane assist, and parallel parking are providing a layer of safety in the market that has proven to be very popular with consumers. Additional safety features employed by connected vehicles and smart cities while also in testing phase have proved (Yue & Abdel-Aty 2018) to reduce automobile accidents and improve safety. This technology exists today as several cities in the United State are currently utilizing in a pilot study.

Connected vehicles, unlike autonomous vehicles continuously receive information from a variety of sources providing real time traffic updates and safety information so that drivers can make informed decisions about where to go, how to avoid road hazards, and be alerted to changing traffic conditions. Additionally, pedestrians, cyclists, taxi drivers, and buses can also receive this information from either their smart phones, enhanced rear view mirrors (Serves as a monitor with messages and alerts), or an onboard screen.
CONNECTED VEHICLES & SEMI-AUTONOMOUS VEHICLES CAN SAVE LIVES NOW!

Introduction

Autonomous Vehicles, when they come will be transformative, disruptive, and hopefully provide benefits that have been anticipated by its advocates. Expected productivity gains, reduction in highway fatalities and the added benefit of providing mobility to individuals who would not otherwise be mobile will help to improve American lives (Mennie 2018 B). With the recent fatal crashes of A/V test vehicles, the public’s acceptance of this technology has waned as represented in several surveys recently conducted. Perception of safety is not matched by the actual record as the public may expect perfection which is just not achievable at this point. While we await the improvements and testing of this technology from a public safety perspective we may want to look at pursuing an avenue that has escaped focused attention. The safety benefits of Level 1-3 autonomous technology which is not fully autonomous and still has driver interface has proven to be very popular amongst consumers. But highway fatalities have approached almost 40,000 per year and this level of death is unacceptable. Why not combine the safety features of semi-autonomous vehicles with connected vehicles and give drivers a greater chance of survival and prevention of accidents?

The technology platforms of connected vehicles which are stand alone are currently being tested in several American cities and are not as complex as autonomous vehicle technology. The technology consists of radio antennas, a receiver, and a specially adapted rear view mirror that displays information in real time to the driver. This information can alert the connected vehicle driver to a wrong way driver, hazardous road conditions, traffic conditions, pedestrians in crosswalks, road hazards, and even safety reminders such as speed limits, stop signs and dangerous curves.

Combine this technology with lane assist, emergency braking, highway driving, parallel parking and you equip a driver with an arsenal of safety features the likes of which have never been seen. It may be enough to give drivers a fighting chance for increased survivability. Why would we not want that, and focus efforts on achieving this?

The Perception

Today, consumers are increasingly concerned about Autonomous Vehicles as they learn more about the technology. Unfortunately, in a consumer study over this past summer (Cox Automotive, 2018), 49% of respondents stated they would not purchase a fully autonomous vehicle (Level 5), which was up from 30% two years prior. The widely publicized recent accidents with Uber & Tesla which resulted in fatalities have not served to promote the safety of A/V technology, thus increasing apprehension. Waymo, Google’s autonomous vehicle division recently recorded its 10,000,000 self-driven mile, plus billions of miles in computer simulation and possess an enviable safety record unduplicated by human drivers. Traffic fatalities are expected to decrease 90% after mass adoption of Autonomous Vehicles (McKinsey & Co., 2015), and connected vehicle technology is expected to reduce vehicle crashes between 15%-70% (Yue & Abdel-Aty 2018). Clearly, the public perception of this technology does not align with the facts.
Expert perception

In a recent article which interviewed Autonomous Vehicle experts (Mennie 2018 B), respondent consensus indicated the positive benefits this technology would bring to society, as well as improve individual lives. Numerous companies are investing billions of dollars in this technology because their information shows the benefits, and the safety that will be delivered.

Public perception

Public perceptions indicate a rising level of concern for this technology not only in surveys conducted earlier this year, but a rather fundamental lack of understanding of the technology. “Sixty percent of Americans know little to nothing about autonomous vehicles” (Ramlet 2018). In order for the public to accept this technology, reduce or eliminate this misperception, an intensive education program needs to be implemented so the public can learn about this technology and their erroneous perceptions can be corrected.

The Reality of the Present

When considering AVs, there are many technologies involved. What they have in common is that all are either safer today than driving without them or are virtually certain to be safer once they are broadly adopted.

Fig. 15- United Nations World Health Organization (2015)

Over 1.25 million people die on the roads annually, of which almost 40,000 are attributed to the U.S. This is an outrageous figure that we have passively accepted with no moral outrage. Where are the protests? Where are the marches? We protest tweets, and upholding existing laws, yet cannot muster the effort to demonstrate outrage and a call for action to significantly reduce this national and world-wide tragedy? If this many people died in terrorist attacks, or earthquakes would there be moral outrage? These deaths are preventable and Level 1-3 A/V technology and Connected Vehicle technology is here today.

Connected vehicle crash rates, dependent upon type of crash showed a reduction of between 15%-70% (Yue & Abdel-Aty 2018) in an analysis of crash data from 2005-2008. The safety features of L1-L3 vehicles (called semi-autonomous because they still require driver control) includes driver assist systems (DAS) such as emergency braking, lane assist, parking
assist, highway driving. There are no safety statistics available evaluating the efficacy of L1-L3 levels of autonomy as compared to connected vehicles. However, all accidents have one commonality- human drivers. The advanced driver assistance features resident within L1-L3 autonomous vehicles can provide that additional layer of safety necessary to reduce accidents by replacing some of the functions performed by human drivers by technology. If we have an automobile perform some of the driving functions, shouldn’t we expect increased safety? Combining connected vehicle and semi-autonomous vehicles would further enhance safety for drivers and provide the best of both worlds, in essence doubling down and giving drivers a greater chance of survivability. There are obviously cost factors involved with added safety features and benefits. Connected vehicle technology equipment is less than $500.00. Amortizing that cost over an 8-year auto life is less than $7.00 a month. L1-L3 technology is significantly costlier. However, it is included in many car models today as standard equipment, while some of the features of L3 are optional at additional cost.

Safety Implications of Emerging Technologies

A variety of emerging technologies are expected to further increase the safety margin compared with how we drive today. Combining and converging the technology platforms that exist within semi-autonomous vehicles and connected vehicles today may help to significantly reduce the number of accidents and traffic fatalities by providing a plethora of safety features that will assist drivers in making better decisions and provide them with vital information so that better decisions can be made. These two technology platforms should not be stand alone. Why wouldn’t a driver want the best opportunities and utilization of the best technology to assist in safety?

Mass Adoption of Autonomous Vehicles

A recent article on the expert opinions of mass adoption of A/V (Mennie, 2018 B) indicate this would not happen well into the 2020’s and beyond (Fig. 2). As a society, we should not wait until this technology is perfected. As a society should we wait to receive the anticipated benefits of a 90% reduction in fatalities (Ramsey, 2017)? Combining Level 1-3 Autonomous Vehicle technology, which is not fully automated and is available now and Connected Vehicle technology should be championed and incentivized. In conjunction with these Level 1-3 A/V technology, Connected Vehicle technology must be added to the equation as well so that we can provide drivers with as many safety features as possible and provide the requisite tools required to make the safest driving decisions. These issues should be elevated to a heightened focus of concern as it is unconscionable that we accept these horrific fatality figures **EVERY YEAR.**
Connected Vehicles

The city of Tampa, Florida has received a $17 million grant from the U.S. Department of Transportation for its Connected Vehicle Pilot Deployment Program to test the validity and safety of this technology. Actual drivers volunteering for this program receive free of charge all of the equipment necessary to participate in the program. The equipment consists of several antennas to transmit and receive information (central business district in downtown Tampa), a transceiver also known as dedicated short range communication device (DSRC), and an enhanced rear view mirror that replaces the drivers existing one. This new rear view mirror serves as a monitor providing real time information to the driver. The program has room for 1600 privately owned vehicles, and as of October 2018 just under 1,000 drivers have signed up. Additionally, 10 buses and 10 streetcars in this area are also outfitted with this technology. The city of Tampa has outfitted crosswalks, traffic signals and other infrastructure with 46 wireless communication sensors that communicate with all of the connected participants providing safety information in real time. Information is wirelessly communicated with connected participants to alert drivers when passengers enter a crosswalk. During congested traffic situations the information provided by the buses will enable traffic signals to modify their timing patterns to ease traffic congestion and assist the buses in maintaining their schedules. Even motorists and pedestrians uninvolved with the program will benefit with improved traffic management by The City of Tampa Traffic Management Center who’ll use real time data collected from sensors and participants to better manage traffic flow. There are anticipated positive environmental effects as when traffic flow is better managed, less idling and congestion will lead to a reduction in exhaust fume production, and increased fuel efficiency.

Smart Cities

Smart cities are those cities have made provisions to utilize technology to communicate with their citizens. Sensors and other data collection devices are located throughout the city and
can provide information on parking, traffic, infrastructure and just about anything else. These sensors can be internet enabled and can communicate via cellular networks, and radio controlled environments. This information can be directly broadcast to users, or back to a server to be combined or streamlined with additional information and broadcast to users. Real time traffic information which includes road construction, accidents, hazardous conditions and alternate routes can be disseminated.

Connected vehicles can use the information provided by Smart Cities as well as other connected vehicles, infrastructure and pedestrians thus providing the most up to the minute traffic information. Smart Cities are not limited just to providing traffic information, but are capable of communicating and providing information on other matters such as areas in need of municipal services, water leaks, and police & fire matters.

**Connected Semi-Autonomous Vehicles**

Connected Semi-Autonomous vehicles do not exist at the moment, as their technologies have yet to be combined. In order for this convergence to take place there must be an increased focus upon traffic safety so that this issue is raised to a level of heightened concern bringing attention and shining a light on the horrific figure of annual traffic fatalities. Both of these technology platforms exist, and in order for this advocacy to move forward and coalesce a champion must emerge to lead the charge. As a society we have become so immune to traffic deaths. Some of the technology leaders such as Waymo, GM, or Tesla could easily advocate for this technology combination as its synergistic benefits could very well lead to overwhelming public support for the acquisition of this non-existing product. Corporate entities are so focused upon commercialized fully autonomous vehicles that this myopia misses a great opportunity to save lives now rather than sometime in the future.

**My Own Experience**

As an early adopter of connected vehicle technology, I am a volunteer for the CV Tampa Pilot program. My vehicle includes Level 1-2 Autonomous Vehicle technology in the form of lane assist, emergency braking and parking assist. This low-level A/V technology, in conjunction with the connected vehicle technology provides a suite of safety technology that provides me with the tools necessary to enable greater safety driving.
Conclusions

While it is impossible to know the future with certainty, the evidence seems very clear that autonomous vehicles will save many lives. Connected vehicles represent a technology that currently exists, but its mass deployment is limited by federal support for the program. Connected vehicle technology pilot programs are limited in scope as their efficacy is being evaluated, and only three cities are currently included in pilot studies. This program should be expanded to include additional cities and be supported by the federal government so that we can do what is necessary in order to bridge the gap until autonomous vehicles are mass adopted.
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Tampa Hillsborough Expressway Authority (THEA), Tampa CV Pilot images


| Interviewee 1 | Dr. Randy Avent- President of Florida Polytechnic University, Florida’s only public STEM university. President Avent recently testified before the Senate Committee on Commerce Science & Transportation on Autonomous Vehicle and was invited to discuss Florida Polytechnic’s expertise on Autonomous Vehicles including its partnership with the Florida Department of Transportations’ Suntrax autonomous vehicle test track, and the creation of the Advanced Mobility Institute at Florida Polytechnic University. |
| Interviewee 2 | Dr. Rahul Razdan is CEO of Ocoo, an internet platform technology company, Senior Director of Special Projects, and a founding member of the Advanced Mobility Institute at Florida Polytechnic University. Dr. Razdan received his PhD. in Computer Science from Harvard University and is an Entrepreneur who has created and sold numerous technology start-ups. |
| Interviewee 3 | Ms. Kelda Senior is the SunTrax Business Development Manager at Florida Department of Transportation. SunTrax is the only large scale facility dedicated to research and development of advanced transportation systems and tolling. Ms. Senior received her MPA from University of Central Florida in Public Administration; Urban & Regional Planning. |
| Interviewee 4 | Dr. Sravani Vadamani received her PhD. from Arizona State University in Transportation Engineering. Data Scientist, |
| Interviewee 5 | Dr. Mostafa Ardakani has two PhD’s: Iran University and Catholic University. - PhDs- Associate Professor Civil Engineering and is an Associate Professor of Data Science & Business Analytics at Florida Polytechnic University. |
| Interviewee 6 | State Senator Jeff Brandes is a State Senator from Florida representing Pinellas County in District 24, and is a state-wide leader in transportation & autonomous vehicles. |
| Interviewee 7 | Mr. Chuck Henson is a local news anchor & feature reporter for Spectrum Bay News Nine, Tampa Bay’s 24-hour cable news channel. Mr. Henson is also the Traffic & Transportation Reporter and features daily traffic updates, as well as interviews and news reports on transportation issues. |
| Interviewee 8 | Dr. M. Ilhan Akbas received his PhD from the University of Central Florida in Philosophy & Computer Engineering, is a founding member of the Advanced Mobility Institute and is an - Associate Professor Computer Science at Florida Polytechnic University. |
| Interviewee 9 | Dr. Dean Bushey received his PhD. from Clemson University in Computer Science and is a retired Air Force Colonel. He is currently the General Manager of Voyage; a company whose mission is to supercharge communities with Autonomous Vehicles. |
| Interviewee 10 | Ms. Carla Bialo is the President & CEO of The Center for Automotive Research (CAR), a non-profit dedicated to researching the global automotive market. Ms. Bialo received her MSME, Material Science-Polymers from the University of Michigan. |
| Interviewee 11 | Ms. Donna Slyster is the CIO Saddle Creek Logistics, a Third-party Logistics provider |
operating in 16 states. Ms. Slyster received her MBA from the State University of New York at Buffalo.

How was the Interviewee Chosen?

Interview subjects were comprised of an eclectic group of professionals. There were four interviewees from academia, four interviewees from industry, two from government, and one from media. They were each selected as they were considered to have expertise in the autonomous vehicle technology industry. Additional professionals were selected, but due to schedule conflicts, timing, or lack of responsiveness they were not among the list of interviewees.

The Interview Questions

Interview questions were developed after an Industry Analysis of Autonomous Vehicle Technology. Numerous companies ranging from automobile manufacturers, software companies, search engine and book sellers are part of the Autonomous Vehicle Technology industry. Extensive testing of Autonomous Vehicle technology has been on-going. In California alone, 60 companies have obtained permits from the state to conduct autonomous vehicle testing on California roads as of 10/18 (California DMV 2018) Meanwhile almost 40,000 American lives are lost each year in traffic fatalities and over one million traffic accidents occur. The perceived benefits of this technology as discovered in the literature review indicate an expected 90% reduction in fatalities when mass deployment occurs (Ramsay, 2015). The question is when are these expected and perceived benefits going to take place?

| Q1. When do you think Autonomous Vehicles will be widely utilized? |
| Q2. What types of benefits do you foresee with this technology? |
| Q3. What types of problems do you think will be encountered with this technology? |
| Q4. How will American lives change with Autonomous Vehicle Technology? |
| Q5. Will existing business models change? |
| Q6. If you were tasked with making five sandwiches, how would you make them? |
| Q7. Will individual vehicle ownership increase or decrease? |
| Q8. What are the ramifications for the industry if individual ownership is reduced? |
| Q9. How will the insurance market be impacted? |
| Q10. How will American’s daily routines change? |
| Q11. How do envision American society with mass deployment of Autonomous Vehicles? |
| Q12. Will Autonomous Vehicle technology lead to greater individual productivity? |
| Q13. Do you anticipate significant job losses in the economy due to this technology? |
| Q14. Who do you see as the dominant companies in the Autonomous Vehicle field? |
The Interview Protocol

Interviewees were contacted either in person, via e-mail, or through LinkedIn, chosen based on their expertise and experience with Autonomous Vehicle Technology. All interviews were recorded using a Sony mini-recorder ICD-PX470), and immediately after each interview the audio files were submitted to Rev.com where they were transcribed. A minimum of 14 questions were asked of each interviewee from questions that were prepared beforehand. Additional questions were asked of some interviewees as the interview warranted. Upon receipt of the transcribed files they were printed for first pass coding review, and then subsequently downloaded in an Nvivo software program where they were coded and then analyzed for thematic commonality.

Interviewee Q & A

Q1. When do you think Autonomous Vehicles will be widely utilized?

#1  We’re really early. My feeling is we’re at least a decade away, if not more, to solving these problems in a sufficient degree such that you will have initial deployments. Then the actual deployment will take quite a period of time because it’s a large passenger fleet that’s out there.

#2  15 years.

#3  Based upon the research and opinions from experts and opinions from experts within the industry, I would say that 2060 is probably the year where we’ll see more autonomous vehicles embedded into society.

#4  So I’m guessing probably by 2025.

#5  I guess it depends on too many factors but probably in ten years. Likely you’ll see that widely spread like of people using probably 10 years.

#6  I think you’ll start to see a little… I think you’ll start to see it creep in starting in 2023 and I think you’ll see wide scale adoption by 2025. I mean, sorry by 2030. More towards 2030, yeah.

#7  Okay, I think that you’re probably talking, its 2018 right now, 20 years, I think. But, I also think on the heels of that, so once you’ve got that 50% in, 20 years from now, I think the next 40 to 45% come really fast. Maybe another five years after that. Because once we get to that tipping point, then there’s no stop, right? Like anything. Once you boil it. In five to 10 years.

#8  Okay so, widely and mass, those are very general terms, and we usually talk in specifics. If I had to say greater than forty percent deployment, if were talking twenty thirty-five.

#9  There’s two levels, level four and level five. And level four autonomous is in geofenced space. And I think we will start seeing that deployed within 2020’s, probably early in the 2020’s There’s two levels, level four and level five. And level four autonomous is in a geo-fenced space. And I think we will start seeing that deployed within the 2020s, probably early in the 2020s, in very congested urban areas. Within five years for sure. Because when you think about the interaction of an automated vehicle with a human-driven vehicle, that is really a tricky situation. And it’s going to take a long time for us to figure out how to do that, with machine learning and AI. But definitely level four within five years. Level five, where we have all autonomous and you can go anywhere you
want; I don't foresee that until the 2040s. So I say we're still a good 25 to 30 years out. And really, it depends how quickly we're able to solve all of the other, not only the technical issues, but the policy, the regulation, the rule making, the certification, liability, insurance. All the public policy issues that surround this.

I expect it'll be 5 to 10 years.

**Q2. What types of benefits do you foresee with this technology?**

I think the first interesting one is just going to be providing access to people that don't have access today. Obviously, this is elderly, kids. Since you can provide this kind of capability in 24/7 access, ultimately you don't have to have a human. That's one benefit. The second benefit on the economic side, it's not intimately tied to autonomous vehicles but the autonomous nature enables it, is autonomous enables sharing, and sharing enables an economic model where the total amount of capital to be spent on cars can go down by orders of magnitude. Therefore, that leads to less need for parking. You can have denser urban spaces, this sort of thing. You can do actually large parts of that already if you essentially take the Uber model and enable it through public infrastructure, but autonomous actually enables it quite a bit more. That's a second benefit. Then the third one is obviously safety, although humans are pretty good drivers. That, in fact, will be the hardest one to demonstrate in high volume. Finally, when you have autonomous vehicles and a bit more control of the traffic system, you can reach higher levels of traffic efficiency.

I think a lot of benefit, as you know, I think there's certainly a lot of capacity to reduce many deaths, to take driver error out, and particularly now that we are so distracted when we drive. Mobility, I think there's lots of potential there, too. I say 15 years until it will be adopted, and I kind of want to actually say more. But, I'll say 15 years. I think that the whole thing where you don't own a car, and you just get on your phone and order it, and it comes and it takes you where you need to go, I think that's even much more out than 15 years. I think that's going to take a cultural change for people in the United States to give up their car, and go to something like that. So to me, that takes longer. Although, younger kids are much more likely to do that. My youngest kid's 16, when he was 16, he didn't get his license. I don't think he got his license until he was 17, 17 and a half years old. He had no interest. So, it may very well be, that this younger generation's much more interested in doing something like that, where us old guys would still have our cars at 85.

The first being again coming from the public consumption side mobility for all. Access. We'll still have a lot of challenges in more rural areas related to CAV because signaling and technology may not be there to support it. But I think in urban areas, our older populations, folks who may not have the means to own their own personal transportation. So, that limits them. They may have to rely on bus or transit systems that may not be all that reliable, particularly in states like Florida. I see CAV as being a tool, a mobility tool to get people where they need to go faster and cheaper. That is more on the side on when we focus in on mobility as a service and shared use. The fact that ownership of
autonomous vehicles, personal ownership, won't be for a long time. It will still be very expensive. But the fact that we can use that technology to build mobility solutions that can move multiple people around more effectively. I see that as the biggest benefit as mobility services for all. Environmental benefits. That's huge. Sitting in traffic and watching hundreds of cars in traffic with one person in them and they are all emitting all types of fumes into the environment. It's a sobering sight. And when we think about the fact that technology can actually shift that and we can actually be better stewards of our environmental resources, I see that as a huge benefit as well. Safety is paramount. I think the statistic is about 90%, 80% of traffic collisions or incidents are caused by the human. So, not weather, not road conditions, not construction, but the actual human. Because we are eating, switching the radio station or we are playing on our phones. Eliminating that distraction and letting driving just be driving is going to be huge and save a lot of lives. So, that is a huge benefit as well.

I think it's going to be a more efficient first of all that's increase the safety as a couple of studies show that deadly accident can be reduced by including autonomous technology and that the benefit is going to be safety also is going to be more efficient system as transportation as a whole.

I think this is the single largest shift you and I will see in our lifetimes. The story really is a story of Artificial Intelligence, and how Artificial Intelligence is really the new electricity, and we're seeing the way Artificial Intelligence handles mobility, and how it interacts with mobility is really the question, I think. To the extent that we really think about how transformative this is going to be as far as mobility goes, this will be the single largest change I think you and I see in our lifetimes, and definitely will be the single largest shift to automobiles in the last hundred years. In terms of safety, in terms of land use, in terms of personal ownership, in terms of dealership models, in terms of service networks, in terms of gas stations, right? The convergence is occurring, right? As the world gets more shared, it makes more sense to be electric, right? Because electric vehicles just ... The cost of electric vehicles, the upfront cost of electric vehicles plays out better if with vehicles being used more than 5% of the day. The share and the electricity work best in an autonomous world. We don't have to have a driver in that vehicle being killed reproductive 60, 70% of the day. So, I think all of those three trends are playing and coming in together. I think the major implications are of course safety, obviously, 95% of all accidents are caused by human error. That's almost 2,500 deaths a year in just the state of Florida. I think you're going to see as far as land use, if you think about the amount of spaces that we have for parking, and the transition that we will see in our downtown core, where you can turn this unproductive parking space into productive space. You're going see this ... but you can also see it in some outlier. So for example, of the number one way that we harvest organs today is your car accident trauma, right? And so, you'll start to see a reduction in organs to harvest. As the world gets more electric because it's getting more autonomous and shared, you'll start to see a shift in gas stations and a repurposing for the gas station model, and the restaurant model, and the dealership model, because the dealership model is really based upon, on a service.
Well, from my perspective, tremendous benefits. From a traffic perspective alone, and I was just having this discussion yesterday with a colleague of mine, interstate travel lanes can be more narrow when they're autonomous vehicles. You won't need as much width between the vehicles because the precision factor. Right now, we make lanes that are 11 to 12 feet wide. Imagine those lanes at only nine feet wide. So, when you've got three lanes on an interstate now, you could have easily four going in either direction. Those travel lanes could also switch direction at the flip of a button. The lane just changes direction. People come off, people come back on. Now, there's a better flow of traffic. I think everybody moves faster. I think everybody moves more efficiently. It's going be more cost effective. I mean, there are a lot of benefits along those lines.

You can read stuff, you can, I don't know, I commute a lot. I drive an hour every day one way. So it may benefit me a lot in that sense, right? I can sleep, right? That may benefit a lot but I think this is just something that's ... the first phase? This is something everyone foresees. I think there are additional benefits such as right now there are people who cannot drive, who cannot drive for several reasons. Either they're really old, okay? And they're afraid of new conditions around them, new generation and they don't trust their reflexes that much anymore for example. Or they are disabled or they have, I don't know, some other physical problem- Yes. So they don't have access to the infrastructure which is their access to all other stuff basically. So I think autonomous vehicles will give them access, which is very important. Of course another very important thing will be for transportation in general.

Well, we will start with what we're trying to do, which is in retirement communities. So you deploy two areas where people have lost the mobility that they cherish, whether it be through physical handicaps, through injury or through age. So one of those, for them, is the ability to regain their autonomy, if you will. The ability to call a car, and not have to rely on a neighbor, not have to rely on a friend, not have to worry about driving. Whether it's because of physical ailments or age. That would definitely be a big one. There's two others, and if you can't tell this next one then autonomous systems are not going to win, it's safety. You have to show, and demonstrate, not just preach it, but you have to demonstrate that autonomous systems will be safer than the thirty-nine thousand, five hundred deaths we had last year in the U.S., will be safer on tricky situations, will be safer in all environments. So that is the biggest gain, the fact that autonomous systems will be law abiding, they will be safe, they will stop, they will avoid the accidents that we're having right now. And then the last one would be traffic management. If you drive down, part of that goes into safety. If you don't have accidents you're not going to have accidents backing up people. But if you can increase the flow of traffic through autonomous systems, where each of them are doing the speed limit, there's no people cutting in front, there's no traffic jams, you can actually reduce the number of, the size of the gap between cars and increase the through of existing roads, without even building any more roads. So those are the three biggies. Mobility, safety, and increased throughput.

I think some of the most important benefits, you hear a lot about convenience and time. But quite frankly, some of our fastest growing populations segments are the 65-plus and people who want to age in place and maintain independence. So I think being able to
provide mobility for all and access for all, typically focused on persons with disabilities, those who have lost their privilege to drive, those who are in underserved communities and have issues getting to house- This is the biggest benefit that I foresee for this technology.

**#11** I think there's a variety of benefits. That depends on what type of vehicle you're talking about. Me personally, I can't wait till it happens. I have way more important things to do than sit behind a steering wheel. Today, I commute 44 miles each way. I would love for that to be productive time instead. Don't get me wrong. It's not bad because the commute is wide open. I do a reverse commute, but still, I would much- ... rather be doing something else. I could be doing work for work. I could be ... Yeah, there's a variety of things I could do. So sitting there and having my hands on the wheel, staring out the front window, to me, is not a productive use of my time, and I do it twice a day, five days a week at least. So to me personally, I can't wait for it to happen. I will be an early adopter.

**Q3. What types of problems do you think will be encountered with this technology?**

**#1** I think we're very much underestimating three issues that are out there. The first issue is how really smart humans are. I tell people, okay, something as simple as obstruction analysis. That is, you see something on the road, and humans know them environment. So if you see a leaf on the road, you know it's a leaf; you know it's tactical behavior; you know you can run over it. If you see a pigeon in the middle of the road, you know it's very likely that as you approach it, it'll fly away. If you see a series of sharp rocks on the road, you know that that's likely to lead to trouble. None of that stuff is intimately connected with driving. In other words, you would never see a driving course in a human world that says, oh, tell me based on all these different things the behavior you would have, but we as humans all know that because we're human. People are very much underestimating how smart humans are and how much it'll really take in the generic condition to get artificial intelligence/AV technologies to be even anywhere close to how good humans are.

**#3** I think one of the biggest will be technology maturity. It still has quite a ways to go before we can implement it on a mass level. Technology maturity, but I think the policy side of it is going to be a huge, and then again going back to the public awareness side will require a series of campaigns. Educational campaigns to go directly to people and talk to them about what the technology means and what it can do for them and prying those keys away from Americans will be a huge challenge.

**#4** The biggest problem is legal and policy related issues, so you need to change all the existing insurance policies, and you need to revise your policies and insurance companies should ... insurance companies and the transportation about it, these should get on one page. Well they're already talking. I'm sure that a lot of discussions going on between the lawyers like the accident lawyers, the insurance folks, the policy makers; there are a lot of discussions, ongoing discussions, and I'm hoping they'll reach to some kind of consensus.

**#5** First is that there are implementations and you see that most of accidents happens
that the drivers hit the autonomous vehicles because they don't understand the culture of the autonomous vehicle. That is one thing, I guess probably because that's a new technology. The culture means that the language.

**#6** I think the major problems that you'll see will be one, just human interaction with it. We interpret a lot of things when we see somebody crossing the street or we say certain activities. We can look at facial signals, we've facial expressions. Right human language. So, I think it's the human machine interaction piece that will be one of the more complicated pieces to work through. I think that largely the other major problem and major challenge, that I think is coming is the labor piece specifically as it relates to truck driving. We're short about 50,000 drivers in this country right now, we expect that number to grow by 2025 to about 100,000 drivers are a huge shortage of trucking, a huge demand for trucking, and yet the biggest pushback we're probably going to get is in this self-driving trucking world.

**#7** Well, I think most of the problems are going to come to the lead up. I think there's a clear recognition that there would be danger in having us behind the wheel and automated vehicles behind the wheel. And the danger isn't the automated vehicles. The danger is us. Because we're the x-factor, we're the unpredictable facture, we're the chaos on the roads.

**#8** I think the complicated systems, we call them interactions, the complicated situations inside the city, you have the bikers, the dogs, the child, you have multiple types of vehicles, you have multiple lane changes; you have round-about. All these complicating factors make it very difficult to correctly train and correctly get an autonomous system to work. If you're talking just on an, I'll use the roads of Indiana, which are very square, very straight, those are one challenge, but when you have multiple factors in a very complex environment, then you throw other factors, such as weather, fog, hail, the unpredictable nature of human interactions, unpredictable characters present several problems for autonomous systems.

**#9** I mean, I think we should think about at different time periods, I think when we start using autonomous vehicles in the traditional traffic, there will be issues like I think when you think about traffic, when you start thinking about it more carefully, traffic includes a lot of human communication, like gestures right? Okay, yes like that. Like a finger outside of the window, right? Yeah. Like a stop sign. You stop but if you're a pedestrian for example, right? There's a stop sign, you trust it yes. But there's this truck coming really fast right? You want to make sure by looking at the driver too to see if the driver saw you or not really. Because okay maybe a bad day for him, he can be playing on his phone right? Of course we will assume that he will stop at the stop sign but maybe he won't, right? So a lot of different gestures are in traffic and I think that will be problem number, maybe not number one but definitely will be a problem that nobody really thinks about nowadays.

**#10** Sure. So from a technology standpoint, I think just making the cars think like a human. The artificial intelligence, the machine learning. Because the things that you think about while you're driving are very complex. So how to duplicate those. And if you start
merging humans with robotic cars fundamentally, you're going to encounter so many different combinations and permutations. I'm not sure if we can ever solve that properly.

**Q4. How will American lives change with Autonomous Vehicle Technology?**

#1 When we solve these problems to a sufficient degree, I think it will change in maybe four meaningful ways. The first one will be, I think, largely speaking, mobility will be a service, and the cost of mobility will go down by orders of magnitude for an average American. For an average American today, the second-biggest purchase that they make is a car or several cars they have. That's a huge amount of debt that they often hold. It's a completely underutilized asset they have to pay for. When you can take on the economic side that down to a service with a much higher utilization model, the cost for mobility and access, access will go up, cost will go down, and availability will go up. They don't have to worry about all these maintenance issues because that's built into the cost of the service. It'll be commoditized, and there'll be several players. Effectively, the average cost for an average American for access to this service will go down by at least one order of magnitude.

#2 Well, routine will be a little … I guess you can imagine that highways will become more efficient. That will be one of the big things, is you can pack the density of autonomous cars much denser so that traffic jams and things like that aren't as bad. So, you get to work a whole lot easier, a whole lot faster than what you could by driving. I think that also getting to work much more fresh, and maybe read an email on the way in, or something like that. So, you can imagine if you play it out where there's a lot of advantages to it in terms of reducing stress in the commute. I think the biggest thing there's going to be a big disruptor in the economy, and you'll probably ask that question later, so I won't get into that too much now. In terms of American lives, I think that if you play it out, and you believe what people say about people aren't going to own cars, and that you're just going to rent them. I think there's ... I think it may have to, because I think the technology may cost so much, that it's hard for people to own their own vehicle, if that's the case. Now, whether, or not, you've got a mixed mode, where people own their own vehicles that are less expensive, and just have some autonomous function level to them, or whatever. And then you have these fully autonomous cars that corporations own.

#3 The adoption of AV technology will be as life changing for America for society as the air plane was. It will completely change how people get around. Not just how people get around themselves but how they get products delivered, how they ship product. It will make transportation more effect for people and goods.

#4 Well I think the major is the time and probably Americans will get to spend more time with their families because I've heard Americans are the most hard-working.

#5 Again, back to the first question is that I think that for the safety and also...I don't think so that it's going to be a full autonomous vehicle. I think that it's going to be a lot of feature added to autonomous vehicle can assist drivers. So having all this technology or assistant to drivers is going to be very helpful for society and the drivers. I mean in
a positive way. As I said, more comfortable, when you're driving you're going to see more comfort, or let's say less stress, and because you have a lot of assistance with features and other things that increase the safety. But that safety again needs to be fully implemented maybe five, six, ten years in the near future.

Well, I think for the most part people will go from owning three cars to two cars to one car. I think at least in Florida, people will continue to own a car a well into 2040, 2050 largely because we won't trust that an APP to get us out of keys for hurricane, right? We want that on demand. We're used to that on demand, but I also think that, that car will largely autonomous features that I think it would be dual purpose, but I think we're still with that comfort factor of having a vehicle on call anytime. I think people will, at least in Florida, go from three cars to two cars to one car, but I still think they will still own a vehicle, but they'll use their second car. There'll be had perfectly fine using an APP for that, and will allow us to drive only and only really when we want to. I think that there will be.

I see vast improvement in our everyday lives. Let's use this as example. I was a latchkey kid. Alright? I'm a banned kid, I was a latchkey kid. So, I had practice to be at after school, I had here to be that, I had both parents working, so they're off doing their thing, there isn't a car to come home, I would have to rely on however I needed to get there. So, when we've got a ton of this vehicle technology, it doesn't matter that you have a license, it doesn't matter that you know how to drive. The car can come get you. Car services, the Ubers the Lift, they will morph into available cars for transport. I don't have to own it.

Elderly, disabled, I think they will have access to many more stuff they didn't have before. Example like the villages, it will improve the cult of service in terms of transportation that you provide to your residents, you customers, however you define them. Right? Plus, I think the real estate sector will be affected a lot.

Dramatically. Over the course of years, though. I always say there are three different ways you can talk about autonomous systems. One is, trucking and fleet. So, we're going to make the truckers, the cross country portion of truck driving autonomous. That's going to greatly change the economy and greatly change the nature of business because, one, we have a big lack of drivers right now, truck drivers. Two, it's going to make it much more safe. You're probably going to have the last mile driven by a human but you're going to automate complete logistics across the United States, so big impact on the economy. Second would be public transportation, which is where autonomy firmly sits. How can you automate the Uber? Lyft, public transportation systems so it serves to increase mobility. I think that's going to greatly change the nature of the American family. You're not going to have three cars for one family, you're going to have maybe one car between the entire family, and you're going to have more of a shared mobility going to have more of a Lyft, but it's going to be a Lyft or an Uber that's autonomous. You're going to greatly increase the amount of real estate that's available, because you don't have to have parking. And then the last one would be, like I was hinting on right
there, residential or your personal ownership of autonomous vehicles. That's probably the
last to make a big impact, but it will be part of the shared mobility part, so it's obviously
going to change the nature of the roadways, gas stationary shops, the nature of everything
is going to change dramatically over the next fifteen years as we roll out all electric, all
autonomous connected vehicles. It's going to change the nature of several industries.

Well, it depends if we have behavior change or not. Fundamentally, I think you're
going to have to have human behavior change, or you're not going to solve the problem.
Which means people have to be willing to share rides, use public transit, do things
differently than they do it today. For one thing, we should eliminate the bottlenecks,
where you sit in traffic for hours, which is just a total- That's big dollars just flowing out
of every car, and plus what it does to the atmosphere. I think we'll be able to lower our
carbon footprint, and it will be able to save people time. I think we'll be able to improve
quality of life for those that today are mobility challenged. Meaning, again, access to
jobs, access to education. But we have a lot of students that would love to go to
university but don't know how to get there. And maybe they can't get into the one that's
closest to them so they need to go somewhere else. And it's impossible. I also see it
freeing up valuable city space, parking spaces that can turn into parks and neighborhood
playgrounds. So the cities can really become the social centers that they used to be. Cities
were originally formed for that purpose, but certainly they've migrated away from that.
Urban planning has to just completely change the way it operates today. Today we design
cities around roadways. We should be designing cities for the citizens and then figuring
out how to manage transit and the delivery of goods. Let's not forget the delivery of
goods. With drone technology and everything that's happening with e-commerce, I fully
see shopping malls are going to go away. There might be a store front or like a Tesla
store, but it's not going to be big malls in the future with big parking lots.

I do think it depends on your age. I think older people are going to be really reluctant
to do it and they're not going to want to let go of what they're used to. I do think the
younger generation is just so used to this kind of capability that to them, they're just
going to naturally start using it. So it really will depend on if that person is very
technically literate and open to sharing rides and things like that. Because I still know
people today that will tell me, "Oh, I won't use Uber. Nope, I won't use Uber." I'm like,
"Why not?" So there is going to be a reluctant for ... And I hate to say use an age
parameter, but it does seem to follow sort of an if somebody is used to having their hands
on the wheel and used to driving. And yet today, I know there's a lot of my friends whose
kids won't even get a driver's license. They're like, why do I need one?

Obviously, in this kind of world you're very likely to move from an asset holding
model, product asset holding model to a mobility as a service, which means it'll affect
the car companies. It'll affect repair. It'll affect insurance, auto insurance. It'll affect the
public transport, that whole eco industry that exists out there. The business models, it'll
affect public planning on the transportation side. Nearly everything in the
transportation sector will be affected by the shift to mobility as a service combined
with autonomous capability. As an aside, don't be surprised as an interim to
autonomous if we have tele-driving as a pretty viable model. Then this is something people haven't talked about. It's just the hardest thing for these cars to figure out is what it is to be human. It's actually quite viable to think about it the following way. We have an AV car that has all the sensor capabilities, but what you actually do is you have banks of people that are driving, but they're elsewhere. It's tele-presenced in. They know, being humans, they can interpret the environment, but by having banks of people in a telepresence context, you can actually get large amounts of the benefit of AV from an economics point of view. You can have banks of people that can flip with each other in an essential way that if you're doing cargo, you can still have very high-level utilization.

#2 I think it may have to, because I think the technology may cost so much, that it's hard for people to own their own vehicle, if that's the case. Now, whether, or not, you've got a mixed mode, where people own their own vehicles that are less expensive, and just have some autonomous function level to them, or whatever. And then you have these fully autonomous cars that corporations own. Earn some money along the way? Yeah. I think that it's like anything, it's like being an Uber driver, and like using Air B&B. There will be a group of people who are more than happy to do that, and make extra money, and they'll put up with the hassle. I mean if I put my Tesla to work, and it came back and was dirty, I'm the type of person who probably would say, "Okay, I'm not doing this again." I'd rather just keep it clean.

#3 Sure. Again, I think coming from the public side, I think it is important to give people a choice. That's what this society is about. Giving people a choice. Not forcing anything upon people. We move and reposition ourselves based on our pocketbook. Based on how economics is affecting us. So, if personal vehicle ownership becomes more expensive as CAV technology continues to advance, the people may be less inclined to want to own a personal vehicle with the insurance and maintenance cost that comes with it. So, if we are relinquishing some of that and then we have, then we understand mobility as a service is a much more practical way to go financially.

#4 Well for the car industry and then it reverberates throughout American business. So for instance, if there's decreased ownership of cars, consumers aren't buying cars, and the technology is deployed, it's going to be less accidents. You may not need as many repair shops; you may not need as many automobile dealers. So speak to me about the business model, expected business model changes?

#5 I guess it's going to be a lot of disruption, especially with insurance companies, definitely they need to change their business model and for car manufacturers definitely that's going to be disruptive... Because all this new technology they have to include their cars in order to remain competitive to other manufacturers.

#6 I think, specifically the trucking business model that the driver is a significant shift, right? There really be brutally mobility companies with very ... with razor thin margins because we've commoditized mobility. Car sale, business radically shifts, I think that we'll see that change out because you have 10,000 dealers and the dealer network today.
How many of those dealers can survive a shift from a service model to an electric autonomous vehicle model? Very few probably will. Well, the entire rental car industry shifts on Uber and Lyft will essentially become platform businesses, by which you can rent everything from a scooter to an autonomous vertical and takeoff system, and with autonomous, with self-driving first and last mile connectivity. We've talked about how hospitals will shift, I think you'll see shifts up and down the food chain. As this disrupts the mobility is such an important part of our lives, and as we see the disruption mobility, we'll see the disruption and everything from regional air traffic to which I think will be much less, because we can drive point to point in a lower amount of time that we could travel via car.

For some sectors I think it's disruptive. For example, the insurance companies. It will completely, it should completely change their models I think. Lawyers' jobs will job. Because okay there are questions that are interesting to think. One, an autonomous car drives itself, has an accident, who's responsible? The owner of the car? The vehicle producer? Loss update coming from the software? Who is responsible? Or is it weighted average? Because did you take your car to the mechanic in the last six months? Yes. You have some responsibility because of that. Did you do the last update? Right? So, I don't know. Who is going to be? responsible? That will be an interesting question and definitely be affecting the insurance companies. So, another problem will be ethics. Ethical decisions. Humans make ethical decisions when they're driving, when they're going to have an accident, there are very typical and standard questions that people have been working on. You have two choices.

There's lots of business models that will rely on autonomous vehicles, or will be touched by autonomous vehicles. Obviously one is, what I'm working on today. I was working on a network connectivity for autonomous vehicles. Because part of what we do is back hall networking with some of our systems. We have remote drivers, that could potentially drive the car from a warehouse in another state. The problem there is we have to change the nature of the existing networks to accommodate such large throughput of data. So, cell carriers, network carriers, Wi-Fi, all of that's going to have to change to accommodate autonomous systems. And I think it will. They are very good at making money so that will change pretty quickly. Right. Now mind you, the cars are autonomous, and their connected in that they provide data and they only require assistance when they see something they don't understand. The cars for Voyage are designed so that they are pretty much self-contained, they are only going to require my assistance when the get into a situation they have not seen before. To do that, I need a reliable, redundant, very fast, high speed fiber network.

Yeah. Well, fundamentally, let's talk the auto business, because that's what I know. Today what do the auto companies do? They design, develop, manufacture, and sell vehicles to dealers. They're really good at that. But in the future you're going to have mobility as a service. So they're going to be selling mobility packages. So instead of just designing a new car every five years, building and selling it to a dealer, getting it off their books, they're going to have a number of vehicles in their fleet somewhere that they're going to have to manage, keep clean, keep personalized, and be able to deliver the right
vehicle to the person as they expect. If a person says, "Five days a week I'm going to use a Volt EB and on the weekends I want a Tahoe SUV because I pull a boat somewhere," they need to have that product ready for that person when they want it. So it's a merger of a bunch different businesses, that quite frankly, at this point nobody has figured out how to monetize.

**Q7. Will individual vehicle ownership increase or decrease?**

**#1** Well, my suspicion is what will probably happen is people will move from a multi-car model to maybe a one-car model. Because ultimately, either because you just like cars, and just like there's no reason to own a horse today unless you just like horses; there's no really utility. There will be people that own cars. Yeah, a hobby, trucks, so there'll be that segment. Then it probably still will make sense in certain contexts to own a car because, as an example, your need to control schedule is so extreme. Really, what we're talking about is, as I said, shifting from probably a multi-car model, multi-truck model; it'll be smaller. I think on the acceptance side, people are very flexible. Actually, it's an area and there's a lot of people that are focused on AV acceptance by the general public and all of this sort of stuff. I just think that's all a red herring because we humans are extremely used to in various contexts turning over control to other entities. As long as either the technology or the process really works in a reliable way that we have confidence in, we just do it.

**#2** I think decrease. I think that there's going to be some people who are going to embrace the fact that they don't have to own a car. Particularly, when you look at demographics these days. Well that, but I know at least it was 10 years ago, my guess it still is, that there's rapid urbanization. People are moving into cities, out of the countryside. And I think if you move to a city, I mean, If I lived in New York City, or San Francisco, or somewhere like that, I wouldn't have a car. You know, I would just use Uber all the time. And we see it. I remember, we went and talked to a company, Luminar, that builds a wiring harness for autonomous vehicles. And the CTO there, he takes Uber everywhere. He has a car I think, but half the time he just takes Uber to work, back and forth to work.

**#3** I think it will decrease. I think we are seeing microcosm of that in cities that are denser, where transit is more effective but even in places like Florida when shared use related to CAV connected to autonomous shared usage transportation, is more integrated into society, I see more personal vehicle ownership going down because you just pull out your phone or an app to call the car, or a shuttle. It comes to get you, it drops you off and then it's on moving other people around, instead of your car sitting in a parking lot for an 8-hour work day. Right. Yes. So, maybe we will see more Uber companies and more Lifts. Those types of business models. Maybe we will see more of those and they'll be the ones, those companies or those entities will be the ones purchasing and owning the vehicles and paying the maintenance companies or suppliers for the products related to those cars. It won't be less personal ownership related to insurance or even law. Personal injury law. All those industries will be impacted but their business models would just adjust. So, for insurance for example, individual owners may not be paying insurance companies directly, but maybe their
insurance coverage is embedded into the cost of that mobility service. So, the cost of
hailing that car or that shuttle for that service. The cost is factored into that as opposed
to insurance cost for a personal vehicle.

#4 It can be both. That's a big change and that's a big “if.” If they're able to convince
the public to switch from conventional vehicles to autonomous vehicles, then the
ownership is going to increase. Then again, if all these ride hailing services like Uber
and Lyft, if they provide their services for cheap, and if they come up with a different
business model of transporting people from A to B.

#5 [inaudible 00:05:33] introduce the hybrid car or electric car and people will say
"Hey, the cost is going be high, so nobody is going use it. But as you see it's kind of a
trade off people, the way they're thinking. We see a lot of people interested in Tesla car
and I think the same thing that applies here. And although the cost, especially at the
beginning, is going to be more expensive that the benefits is going be more than the
cost. For car manufacturers is not going to be that much because still people are going
use their car but I don't know exactly what the prediction but I think it's not going be
that much complication for car manufacturers.

#6 Yeah. It's incredibly disruptive, this whole paradigm begins to shift on mobility as people
purchase less cars. It's not saying that car store made, they're just made very, very
differently. Their standard frames are standard, they're standardized and brands fail Cease
to matter as much. For example, we can just take this experiment, I mean when was the
last time you got in an Uber and you cared about the brand of the car that you got in?

#7 I sure would like it to. I think- Everything changes. So, one door opens, one door closes.
So, if we're talking about car ownership going down, believe me, I don't know what it
would be, but there'll be something else that will replace that that will take that position.

#8 I feel like... I shouldn't say feel. According to the research I've been reading, especially
stuff related to mobile TSS service. It looks like it will decrease which makes sense.
Because if the vehicles are autonomous and if your traditional car right now sits in a
parking lot 95% of its time okay? I think that's the average for an American ... own car.
So then it makes sense to have vehicles as a service. They already do that; some
companies already do that. Okay, they send you a car ... sometimes you need a sports car-
Yes. That is one option. But another option is there are these autonomous vehicles going
everywhere, and you use them only when you go to work. That's also another option. So
both are possible but what I feel like is owning one will be more expensive even if you
make it work for you. Owning one will be more expensive than just using one whenever
you need.

#9 Correct. Now there has always been a question is Autonomous vehicles going to
increase or decrease traffic? I think in the short run, when you have mixed use, when
some people are using their own vehicles and some people are using Autonomous
vehicles, there's a great potential for an increased amount of traffic, people are more
willing to travel, people are willing to go out when maybe they wouldn't have before. But
I think, when we get over the hump and you have majority I think the complete
ownership, or the number of cars people own is going to go down and the traffic situation
is going to get much better. Well, let's start with the easy two, lawyers and insurance.
They know how to make money. We've already talked to the insurance executives, and
they've talked about amortization charts, and how they are going to charge liability and
how that's going to change the nature of them insurance model and they have already
assured me very directly that they know how to do this, they are already on top of it.
When this change happens, they will be ahead of the game. Yeah, they already have
studies out there, and they will figure out. of course some will go to the wayside, and
other insurance companies will come on. But how are they going to do it? Are they going
to sell insurance with the automobile? Is the automobile going to be insured? and not the
individual? How is the model going to change? It's going to change, but they are going to
be on top of it. And anything with lawyers... if the lawyers have started studying this,
again, they are very good at. They're very smart. And it's a very good group. So they
will be ahead of the game. So I'm not too concerned with the lawyers and the insurance
companies. As far as the auto manufactures, they are facing a revolution. And it may not
be that you have (inaudible) anymore, (inaudible) are going to start teaming up with the
smaller companies, like Voyage, Uber, Lyft, Waymo, Apple. And some of the
manufactures of tier one and tier two components.

#10 It will decrease. But it's hard to say by how much The vehicle miles traveled may
change. And I think that's the metric we have to look at, versus number of vehicles or
anything else. Fundamentally, it could. Say there is a two-car household today, you could
easily go to one or to one. It depends how many mobility service providers are in your
area, and if they provide you with a seamless way to get around. Seamless means super-
easy. One app that you can order up whatever you need, you don't have to wait, less than
five minutes. You can pay for it all out of one account. Like your cellphone package
today. You do that for a mobility package. You get different levels depending on your
need.

#11 Yeah, I do. I do see a lesser need. Like for example, right now my husband and I both
own two cars. As a matter of fact, we own more than two cars, but down the road, I
would envision ... Maybe I'm not ... He won't be ready to give up his car because he's not
an autonomous-type person. He likes being able to be behind the wheel. But I could
easily see us getting rid of one car, and then just having one car for the two of us and then
supplementing with autonomous capability.

Q9. How will the insurance market be impacted?

#1 On the insurance side, insurance is largely a game of managing risk of
individuals, and obviously in the AV world you're not managing risk of individual;
you're managing risks of cars or operating systems. So they'll have to figure out how
to manage ... Well, yeah. Monetize that model and how to shift, because no longer will
people be that individual. I no longer need Geico Insurance.

#4 They would definitely be at a benefit because the premiums are going to skyrocket.
#5 Definitely that is going to be impacted in a positive way because we're going to see a huger significant increase in safety, as I said there are different studies that show the [inaudible 00:07:03] deadly accident can be reduced by including autonomous vehicle or features of autonomous vehicle and as a result, the insurance needs to change its business model and of course it's going to be less expensive for drivers.

#6 Yes. So, you're going to go from a B to C model business to business, to consumer model to a B to B model, which is business to business. Correct. I'm going to sell one policy to Uber, right? And that policy will cover all their autonomous vehicles. Have a radically less revenue, right? You're...It's probably $500[inaudible 00:16:41] from insurance being purchased by the vehicle insurance space today. That will be radically less one because you'll be less accidents, but two because your ... I will understand the portfolio of risk so much better because I don't care that it's a 16-year-old boy getting the vehicle. It will be, I know that it's the 3.0 or 15.0 software update, and that's what I'm ensuring, I'm insuring the software update.

#8 For example, the insurance companies. It will completely, it should completely change their models I think. I'm not sure. Because insurance companies will find a way to revenue.

#10 There's several things that the insurance companies need to think about. In the upcoming years, it's almost going to have to be insurance for the Internet of Things, because everything is getting smart, and all of your assets are being linked together by your phone. Even to your refrigerator, to your bank account, to your car, to everything. So how to insure the Internet of Things, I think, is the interesting thing.: And then, from a transit perspective, it's not insuring the vehicle and the driver anymore, but it's insuring however, the customer is choosing to get around. So there's a number of scenarios. Let's say, most days you ride your bicycle, but two days a week or two days a month, you get a car to go or something like that. So you're going to see where you can just buy insurance by usage. You're going to see a lot of the Ubers, some of the big mobility service providers, they're going to self-insure. They're not going to do that business through the insurance company. So they're going to have to think about how to modify their packages so that people can be insured. For example, if I'm using, let's say there's one app, and one day I take a trip. I'm on the subway part of it, I'm riding my bicycle part of it, I'm walking part of it, and then at the end of the day I use Uber to get home. I need to be insured in all those cases. And I don't want to have to re-up each time. So how to create that kind of package to keep people insured regardless of mode of transportation?

Q10. How will American’s daily routines change?

#1 Well, maybe a way to say it is if 90% of Americans today are in the car world and 10% are in big cities where they're very used to public transportation or things like Uber, well, maybe it'll flip. It'll be 10% are in the car world and 90% will have a behavioral interaction model that looks a lot more like when you're in a big city like New York City.

#2 Well, routine will be a little ... I guess you can imagine that highways will
become more efficient. That will be one of the big things, is you can pack the density of autonomous cars much denser so that traffic jams and things like that aren't as bad. So, you get to work a whole lot easier, a whole lot faster than what you could by driving. I think that also getting to work much more fresh, and maybe read an email on the way in, or something like that. So, you can imagine if you play it out where there's a lot of advantages to it in terms of reducing stress in the commute. I think the biggest thing there's going to be a big disruptor in the economy, and you'll probably ask that question later, so I won't get into that too much now. In terms of American lives, I think that if you play it out, and you believe what people say about people aren't going to own cars, and that you're just going to rent them. I think there's ...I think it may have to, because I think the technology may cost so much, that it's hard for people to own their own vehicle, if that's the case. Now, whether, or not, you've got a mixed mode, where people own their own vehicles that are less expensive, and just have some autonomous function level to them, or whatever. And then you have these fully autonomous cars that corporations own.

#3 I see American's daily routines changing once CAV is fully implementation or when any technology is fully implementation into our society. I see American's live...I see quality of life improving. Going back to our discussion about you can do more... You can do more activities in a vehicle that is driving itself. You are not having to worry about the stress, the anxiety, the cost that comes with owning a personal vehicle can be a lot for some people. Particularly lower income, right. If you work 45 minutes to an hour away from where you live because you have to live further away because the rent is too expensive near your job. Then, you have more access you will be able to get to where you need to go faster, with less stress and be more productive on your travels. So, I see quality of life improving for Americans once CAV is fully implemented.

#4 There will be a lot more trip chaining. Okay so trip chaining is essentially multitasking. So since you're in an autonomous vehicle and your essentially not really in control of the wheel, while you're driving from home to work, you can probably get another set of multiple tasks done while you're sitting in your car and working. There will probably be a lot of empty trips as well, so you can just ask your autonomous vehicle to go to a public's or something and have your groceries delivered or something, so there will be a lot emptier trips.

#5 I guess it's again all depends on too many factors, because you're going to see more traffic flow and more, not only because of autonomous vehicles, because of other technologies, I think it's going to... Like all these advances to technologies; all those GPS... Yes, also connected vehicle and because just autonomous vehicle is not an isolated entity: It comes with other advances connected with other advances in technology. I guess it's going to be more convenient for people and more access for other people.

#6 Well, I know that I need milk and eggs, bacon and these 15 products every two weeks. I know that's the standard thing for our family, but I'm still going to go find specialty
things when I need them and I want to have that experience too, but in the future all ... Press the button and jump in the vehicle be there in a couple of five minutes, and that experience will be very different. Frankly that stuff could all be waiting for me as soon as I get there.

#7  I think that, given the personal impression, that there will be more available time for me with AV technology. If ... ... I don't have to take ... [inaudible 00:18:20] what am I going to do with it? I don't know. Same thing I do with it now. Fill it with nothing. If I don't have to take the kids somewhere ... ... then, that frees me up 25 minutes there, 25 minutes back. If I'm not worried about my car ... well, I might still be worried about my car in the shop, cause they're still going to break. I mean, they will fail in some way. Whether that's a tech failure or a physical failure.

#8  Yeah. Daily routine. I think daily routine will change a lot because I think, I'm assuming now ... you think about it separate but I tend to link them together, like connected and autonomous vehicles. I'm assuming connected-  Solved.

#9  I'll tell you what, I'm going to stay away from plain communities that offer autonomous vehicles as part of the community. I'm going to assume the same American model, I do think we're going to have more time with your family, and I think there's going to be better utilization of your time as you commute. Whether people are going to be willing to commute longer, I'm not sure, I'm not sold on. They may be. But I do think there will be better utilization of their time. You're right, I like the idea that there will be less ownership, and less depreciation in value, like the car. So that's going to go down. I agree.

#10  Well, I think, it sounds scary, but I really believe that your day is going to be so simple in the future. For example, we all have wearables, or many of us have wearables. This isn't going to go away. And those wearables are connected to your phone, which is connected to your car, which is connected to your bathroom scale. Everything is connected. So in the future, your phone will wake you up, or your wearable will wake you up, and your car is already going to know, or whatever mobility device you have, is already going to know where you’re going, what time you need to be there, and the car or whatever is going to be there to pick you up when you need to get there. And on your way, it may suggest how you should eat that day because it noticed how you slept, it saw what you weighed on the scale, and it knows your parameters in terms of what you have in terms of how much exercise you want, et cetera. I know. And then it's going to tell you, "You know what? Your refrigerator told me you don't have milk. And the cheapest place to buy it is at Kroger's. Shall I pick that up for you while you're working today?" or whatever. And already your habits are more known than you believe. But I think it's just going to make a tremendous difference. And what I hope doesn't happen is that it doesn't dumb us all down and put us in this era of, "I don't have to learn anything, and I don't have to do anything because everything's so simple." But I really think this kind of intelligence is coming. I have Alexa in my house, and she says things to me sometimes, I'm wondering what she's listening to.
Q11. How do envision American society with mass deployment of Autonomous Vehicles?

#1 Yeah. I think we'll have a large number of the benefits, and it'll be like any of the technological shifts that. I think so, yes. I mean, we will go through a period where we're debugging the AVs and all that, but let's imagine a point where we've fixed these problems. Okay, yeah, I think the vast majority of these things which are related to distracting and drunk driving will obviously go away; by the way, maybe not unlike what happened in the aircraft industry? What happened at some point, there used to be barnstormers, and people died all the time and all that, et cetera, et cetera. When we got into a regime of, as it were, a high automation and high regulatory burden, really aircraft travel is extremely safe. Then what will occasionally happen is a software bug will go out, and a whole bunch of people will die because of that. Yeah. In fact, as it were, instead of one drunk driver affects, whatever, a small number of people, these kinds of technological shifts may actually affect a large number of people. Therefore, you'll have to figure out how to handle those kinds of things. It'll have a slightly different feel, but yeah, I think it'll have a positive impact. I actually think the safety impact will be positive. It'll take the longest to realize. The economic impact will I think be the most profound. Because as you know, for an average household in the US, their auto payments and maintenance and all that stuff is the second biggest, if not the first biggest depending on whether they rent or not, expense they have. The other way to look at it is if this goes forward, the amount of savings that an average American will potentially have can go up significantly because there's no longer an asset that's getting 4% utilization that they're paying for. I suppose the next interesting thing or retirement. You can use it for many things. It'll be used for all sorts of things, but whatever the next interesting things coming out of whether it's technology or, what do you call it, real robustness in their own finances. Most in the baby boomer era, most people don't have enough retirement, and so you could well imagine these kinds of shifts.

#2 I think transportation becomes ... It’s not a limiting factor anymore. I hear, I know we have a company here in Lakeland, that was working on pill dispensers that were just like vending machines. They would put them in doctor offices, so when you came out of a doctor's appointment, you go right up to the pill dispenser, and put in your little card, and it actually gives you, your pills, right then, and there. So, you don't have to go the pharmacy. One of the driving reasons they were doing that, is they found that most poor people can't get to a pharmacy. So they go to the doctor, they get the medicine and everything else, and they never go get it filled. So, they have no way of getting to the pharmacy to get it filled. So, you take away a lot of things like that. You look at Vistage, here in Lakeland, that works with elderly people, and they have volunteers that pick them up, and take them to doctor appointments, and they go get food for them, and those types of things.

#3 I still believe that by 2060 we still won't be fully AV. There will be some people that are still clinging, there won't be very many but I still feel like that will be a part of it because my hope is that it is still presented as a choice. Maybe the folks that are still I driving their own personal vehicles are maybe they decide they have more money and
they wanted to pay the extra expense. So maybe the government now is charging additional money. Like if you are owning a personal vehicle and driving a personal vehicle maybe now your cost is 10 times more in 2060 than it is now.

#5 Yes, less stress, and as people realize the benefit of autonomous vehicle, I think it's going to be more desire to have autonomous vehicle and using that technology in their car and again, there are too many unpredictable that would happen, so nobody knows but... Who knows, you're talking about in the next five/ten years. Assuming based on the initial study I think that the next 20 years, people are going to realize the benefit... Yes, because again, that's in the transitional period that we get used to the traditional driving and still most people they're afraid that they don't have the control of their car. So that's needs to a culture.

#7 You know, what I had in my head as you said that was a vision of people in vehicles, with screens in front of them, being fed data and information and entertainment and things like that while they're in their car.

#9 Wow. I'm going to say it's not going to be changed at all. I think it's going to change the ability of people to make choices, and the ability of people to live where they want, and the rapidity at which they can get business done, same nature of going from horse drawn carriages to cars, I think the same impact. So, did somebody who was in nineteen oh two, driving a horse drawn carriage, ten years later, they are in cars. Their lives are the same, it's just, the rapidity at which they can get things done, and the places they can go, will change dramatically.

#11 I think it'll just become the norm just like a cell phone is today, to be honest. Right now we're at this cusp of something, of new technology coming out, but it will just be the way, and people will look at me when I say that I used to have a car and I drove my own car. People be like, "Why?" Just like people can't imagine not having a cell phone. It's like [inaudible 00:18:54] and basically having ... Oh, and by the way, we used to have a GPS device, and we used to have this device, we used to have this device. And this device, now it's all on my smartphone. It will just become the norm that people will be like, "Why would you ever have done that? Don't understand."

**Q12. Will Autonomous Vehicle technology lead to greater individual productivity?**

#2 Well, routine will be a little ... I guess you can imagine that highways will become more efficient. That will be one of the big things, is you can pack the density of autonomous cars much denser so that traffic jams and things like that aren't as bad. So, you get to work a whole lot easier, a whole lot faster than what you could by driving. I think that also getting to work much more fresh, and maybe read an email on the way in, or something like that. So, you can imagine if you play it out where there's a lot of advantages to it in terms of reducing stress in the commute. I think the biggest thing there's going to be a big disruptor in the economy, and you'll probably ask that question later, so I won't get into that too much now.
We become more productive right because we are not spending time sitting in a vehicle a lot of times in traffic. A lot of time quality of life will most certainly improve.

Trip chaining, trip chaining, and then empty chaining I guess] Did I make that word up? I'm sorry, what's the word empty trips? So instead of time going to the store, you can send your car there and where do you think that productivity is going to be utilized? Well trip chaining probably you can utilize it just for working, so instead of you spending time behind the wheel running errands, the car can really do that for you and then you just spend the time working.

Yeah, if people can get safer and faster to their jobs, yeah.

It will create opportunities to have greater productivity but I cannot say it will because as I said, just like any other technology-

Yes. Yes, Necessarily so. You are going to have more time, during the day. Whether it's time you can utilize while you're driving to work, you can actually get your E-mail's done. Or... time to de-stress, when your driving home you can watch Harry Potter, so when you get home you're all de stressed. I think your time will be utilized much better.

Well, that's an interesting question, and we debate this all the time here in the office. We talk about the good old days when you didn't have cellphones and didn't have computers, and gee whiz, we still got business done and were pretty productive. If we think about giving people more time where they're not driving a vehicle or stuck in traffic, yes, it should be able to improve productivity. You should be able to do many things and multitask more than today. If that's good or bad, I think, remains to be seen, quite frankly, because people are already overstressed and overstimulated by all of their devices.

Oh, I do. I mean, I look around. And plus, I look at even in this office, some of the people, it also will reduce people's stress. Because fortunately my commute is relatively stress-free because it's a reverse commute. But people who have to drive on I-4, health conditions. I mean, the stress on their bodies driving through all that traffic all the time. I couldn't do it. I wouldn't be able to go that route because it's just not worth it to me. And even here in Lakeland, there's people that live here in Lakeland that their actual physical commute is a lot shorter than mine, but the time that it takes is equal to it. And that's because there's a lot of one-lane roads, so you're sitting in bumper-to-bumper traffic versus if you Yeah. So I do think that there'll be less stress on people from a health issue perspective. So there's other benefits such as that that I didn't even mention yet.

Q13. Do you anticipate significant job losses in the economy due to this technology?

I don't know. Not, really sure, I don't know how ... I know with the trucking industry, or logistics industry, one of the things that I hear them say the most is that they can't hire drivers. So, I know that driver is going away. They can't wait for
autonomy. I don't know if it's the same around cabs, and those types of things, or not. But, I think around cars, it may shift some. I guess, again, it's more of an AV issue, I mean an EV issue, then an AV issue, that I guess electric cars are a lot more reliable. Lot less moving parts, so a lot less mechanics, but you're still going to need mechanics. I guess you're going to get a lot of body shops that go out of work, you know, a lot of gas stations that could potentially go out. We had Tesla here last week. Mm-hmm, and they want to put charging stations on campus. And they say that charging stations is the next impediment to adoption? You know, first it was performance, Tesla took care of that, then it was price. And they argued that Tesla's taking that with the 3. And they say the next one is charging stations, and I asked, the question, I said why aren't you going to gas stations? If I owned a gas station, I would be a little bit nervous that electric vehicles were coming around, and my gas station is not going to be relevant anymore. I probably would be putting electric charging stations there to start making the jump.

#2 Yeah. I mean, that's very hard to tell, but in general what's going to happen is what's been happening at every other industry, which is that the employment will move from ... We're going to have less number of cars, but the cars will have much higher electronics content. The manufacturing on the electronics side and the design on the electronic side will rise in employment while the traditional auto manufacturing assembly will go down in employment, just to give an example in that little subfield. There'll be a lot more software people. There'll be a lot more electronics people in that world. This is just on the manufacturing side. Repair, gasoline engine, traditional distributed repair models may change to fleet level, largely fleet level, highly automated repair models. Well, I mean, it creates a social upheaval principally as a function of what level of ... bridging technologies or education is provided to the people that are there. I mean, just as a complete sort of example of this is if you go into the field, the auto guys of course, the UAW might be affected, but the equivalent of the UAW on the electronics side will go up. The question will be where is that manufacturing going to happen and then how do you control that. Education and retraining and these, which have always been the case.

#3 I don't know if there will be a major reduction in employment or if the employment would just change for those individuals. Yes. That is what I would assume. The need would still be there, particularly for a long period of time from technology maintenance side of things. I see the industry shifting but if certain jobs or positions are eliminated I see the business side of it adapting or adopting to those changes.

#4 It depends on the industry. Probably you will see a significant job loss in the automobile in the manufacturing industry. They'll probably have to find something else if they're multi-skilled and if they can transition. There will also be significant addition to jobs as well because even though it's an autonomous vehicle, I think will be more of an addition to technical jobs.

#5 No I don't think so. No.
I can't. I don't think you can look at automated vehicles, as the cause of mass unemployment. I think it is a symptom of AI. Yeah, it's a symptom of AI, right? And so, whether it be here or in the workplace or with virtual assistants or whatever, you see the general trend and I think that's what we saw. Yes, and no, but I mean like one of the questions I ask is when do we graduate our last class radiologists? Like when does AI, be able to read an x-ray better than a human radiologist, quicker, annotated instantly?

And I don't. Yeah, I don't anticipate that. And that's a tried and true message about time. So currently and during this last presidential election cycle, there was a whole lot of discussion about coal and coal jobs and mining jobs. Those jobs are never coming back. We're never going to do that again as a country. Those people will have to morph into the next level of ... through training and everything. So, I think the exact same thing. My answer is no, I don't think that. There'll be different jobs. Look at the Tampa International Airport right now. The shuttle bus drivers that took you from Economy parking to the terminal. Those guys that are somewhere else in the airport now. But, I asked specifically, by the way, if they were all being laid off ... ... and they weren't. They were all being moved to other jobs.

No, I don't. I don't think so. When cars replaced chariots or horses, did some people lose jobs? Yes. But did it create- No, no, it will probably create new markets, new jobs. It may change jobs but I don't think ... the number of jobs to fill probably will increase.

Significant job increases, yes. I agree there should be a lot of jobs created. Massive, massive increases. Now, the nature of the jobs will change, dramatically. And I think it's incumbent upon companies like Voyage, companies that are bigger, to take that into consideration. We hire the smartest engineers, and we are incredible as far as a company. But I think we also need to reach out to existing companies, mechanics, transportation, engineers, people in the auto industry, to make sure they have an opportunity to be retrained, and utilized. Some of them have the ability, and the desire, to adapt to the new technologies. It's often times easier to hire a twenty-one-year-old, but I think it's incumbent upon us to make a concerted effort to reach out to those and teach them about autonomous vehicles, and how to repair them, and the components. As you know, they are not that, probably a little more difficult, and I don't think we're going to get... engineers we need to hire out of college and get the top knowledge but there is going to be several jobs that just need cross training.

Well, yeah, because with autonomous cars, they're going to have to continue to evolve and you're still going to be manufacturing cars. So they'll always be people that are doing the design work and envision what cars can be like, and they'll still be people that need to do the mechanical. It'll be a bit more technical, but mechanical type of work. So I do see it as a trade. And oh, by the way, like I said, all that excess time I'm going to spend it doing something else and spending money at it. So it'll open new jobs on the other side.

Q14. Who do you see as the dominant companies in the Autonomous Vehicle field?

Ford, Toyota, Mercedes. What they bring to the table is immense, obviously,
experience in the automotive and scale manufacturing and safety and these kinds of things. Then we've got the high-tech club, which is Google, Uber, Lyft, and a whole host of startups coming out of Silicon Valley. Then we have what I'll call the infrastructure club, which is people like Intel, NVidia and the sub-system suppliers underneath them. Any one of these clubs or a company to these clubs or somebody we don't even know yet could easily dominate going forward. You could see a path where Google says, "Okay, guys, I'm going to be build the OS and the basic AI technology that all of you license, and you guys are just the manufacturers." That's kind of like what Intel and Microsoft did to the PC industry. You could see another model where these OEMs, the automotive OEMs say, "No, no. We are the ones that know how to do the volume manufacturing and things like that, and we'll be in the control seat. We will sample technology from various folks." You could even have somebody like NVidia come along and be like a Qualcomm in the cellphone industry where they say, "Well, we provide the vertical stack that actually solves 90% of this problem, and we're going to control it, and you use it."

#2 I think I kind of had this little spiel that when I've been given presentations that DMT gets, I just say that, the days of combustion engine cars, with knobs and controls on them, built by Detroit, and driven by people are numbered. They're going to be cars that have electric motors, that are software defined cars, driven by autonomous agents, and built by computer companies. They're going to be interconnected computers with electric motors.

#3 Well of course we know the Teslas and the Waymo's of the world are at the forefront but I still see Uber and Lyft, I am excited to see Uber and Lyft because I feel the shared transit use mobility as a service use concept is going to take off. That is going to be the first wave of CAV that we will experience.

#4 I think it's pretty varied, and it is competitive so I think secretly everybody is working in the back and not letting anybody else know.

#5 I guess in long term, I guess if everybody going to use, or if they want to remain competitive if they convert to autonomous vehicle, I guess majority of companies going that big. I don't know just any single company that's going to dominate. I guess majority is going to [inaudible 00:13:17] shift in that. I know that Toyota is doing a lot [inaudible 00:13:32] that the other companies are doing the same, like BMW, Mercedes Benz Ford also. Actually was another import. I don't remember it was a couple of years ago, it was a six company they created kind of like a consortium or a data study on autonomous vehicles study. And I guess the majority of them going that way. You cannot just think about one company, because a majority are going that way.

#6 Let me think, by far Google and Cruz are two of the most well-known dominant companies, but I think that there is also the second tier of companies that are I think on there'll be clear leaders, but I think by 2030, 2035 there will not be because it's commoditized, right? There'll be a lot of players in the space because generally everybody's kind of figured it out.
I think that, when it all comes down, I believe that all of the players that we see today will be the same players 50 years from now. ... you know, Ford and General Motors. Tesla's going to have a big part of that. Companies like that. I think that the Asian companies, Kia and those folks, are going to ... and I don't know who the ownership is of those brands ... ... but, whoever the ownership is of those large, they're already doing it. And if they're not doing it, then they've already missed it. My news director said something to me once that was so poignant that it's stayed with me forever and it's relative in a lot of terms. So, something was happening one day that I was like, "Mm, I don't know if that's breaking news or not. Maybe I should break on it. I'm not sure if I should break on it." And she goes, "If it makes the hair stand up on the back of your neck, you should've already broken on it." And if those manufacturers today, this year, right now, haven't already broken on that.

Audi, Waymo, Uber, Lyft, and Apple. Oh, and you can throw Sport in there, too. Of course, I could probably take Uber off the list now, Because of the accidents, so you're going to hit some speed bumps, in such a volatile technology, especially small companies like Voyager, or companies that a lot to lose, any one nick up could cause them to bail out of a technology. So I think that will always change, I do think that, especially Audi and Waymo, they Have made such significant advancements in the technology, that they are going to continue. Apple may, for instance, develop the technology then back out of the autonomous vehicle but apply that to somewhere else. Those I think will continue to be your dominant players.

Names? Okay. Mercedes, BMW. What they did, let me tell you, they collaborated. They formed partnerships with ... Yes. Not only software but also processor manufacturers like Intel for example.

Those that are leading the pack right now are GM and Mercedes, BMW. They're the ones that have the highest-level technology and some of the better partnerships on the data side. And I think that's what's going to- You have to be able to complete the whole picture, which includes the data side. So when you look at some of the things that they're working on, some of the things they already have in the marketplace, and some of their partnerships, that puts them towards the top. Of course, Tesla is still doing amazing work, and they came out with their, I would say, two-plus software already. Cadillac has the Cadillac Cruise that's out. They're right up there with those automakers as well. But those are the ones that are truly leading the brigade right now. Oh, gosh. I was thinking just automakers. Waymo is way up there too. They're the ones.

I think everybody knows Google is rushing to it. I don't know if Amazon someday might enter into the space, to be honest with you. And you know the ... You know, like Ford and the rest are also trying to do it. So ... I'm trying to think. Who is the other one that always sends out autonomous cars?
Background

Professor Jim Mennie is a Business Analytics Instructor at Florida Polytechnic University in the Data Science & Business Analytics Department since 2015. He holds a Master’s Degree in Business Administration from Long Island University and a Bachelors of Arts degree in Political Science from the State University of New York.

Professor Mennie has 25 years of experience in improving a broad range of business operations including sales strategies, supplier relations, technology integration, logistics & supply chain management, project management and increased profitability. He was President of a Spring Hill, Florida nursery where he developed and implemented a business plan creating a retail and custom design operation. Prior to that, he was Vice President of a family-run business where he helped to increase production, sales and profitability. He was also Director of Distribution and Facilities and Director of Operations for Manchester Technologies in New York, a $300 million value added reseller.

The IA Protocol

- The scope of this analysis included only the United States Autonomous Vehicle Technology industry. While research and investment within the autonomous vehicle industry is world-wide, for the sake of this study, the scope was limited to within the United States. Google Scholar, Google, Bing, and Ebsco databases were utilized. University of South Florida, and Florida Polytechnic University library resources were utilized. Gale Cengage Learning utilizing Academic One File, Legal Trac & Business
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- Search terms such as Autonomous Vehicles, Autonomous Vehicle Technology, Connected Vehicles, Connect Vehicle Technology, Autonomous Vehicles were utilized in the search of all of the data bases mentioned previously.
- Government and industry charts were utilized in the paper which were open source. US DOT, FDOT, SAE, were among the sources utilized to provide some of the charts and graphs utilized in the article.
- Interviews from 11 industry experts were utilized for perspective and thought regarding what areas of research required additional study. While there was a plethora of information regarding the topic, there are very few research studies on the perceived benefits of Autonomous Vehicle technology. Specifically, a dearth of material exists on the combined technologies of Autonomous Vehicles and connected vehicles. While each separate platform brings forth its own benefits, how will combining these two technologies now impact safety, productivity, mobility? Another study examining these issues is needed.
Permissions

All interviewees were asked permission to record the interview session for purposes of accuracy, and record. Prior to beginning the interview. All subjects were advised they were being asked questions regarding their thoughts and perception of Autonomous Vehicle Technology and that their answers were being used in an article being written in fulfillment of the requirements for the authors DBA degree. All subjects agreed.
All charts and graphs were secured from open source materials from the federal government and some of its agencies and departments.