Surveying Florida MPO Readiness to Incorporate Innovative Technologies into Long Range Transportation Plans

Draft Final Report
Prepared for

THE FLORIDA DEPARTMENT OF TRANSPORTATION
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DISCLAIMER

METRIC CONVERSION CHART

U.S. UNITS TO METRIC (SI) UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

METRIC (SI) UNITS TO U.S. UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

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16. Abstract

There is optimism that Automated Vehicles (AVs) can improve the safety of the transportation system, reduce congestion, increase reliability, offer improved mobility solutions to all segments of the population including the transportation-disadvantaged such as the elderly and disabled, and improve the quality of life of all people. The recently enacted HB 7061 stipulates that the Long Range Transportation Plans (LRTPs) in Florida consider the infrastructure changes needed to accommodate advanced vehicle technologies such as autonomous vehicles. This study reviewed current LRTPs of Florida MPOs with regards to AVs (About one-third of all MPOs include AV-related language in their current plans) and conducted a survey of MPOs to assess their opinions and needs. Overall, 23 of the 27 Metropolitan Planning Organizations (MPOs) had provided responses. The survey responses indicate that while MPOs are not skeptical of AV, there is much uncertainty in the anticipated impacts of this technology on attaining their planning goals. Further, the surveys clearly point to the MPOs need for information. This study undertook a synthesis of literature to address these issues, and this is included in the final report. Finally, a set of recommendations are developed for FDOT to assist MPOs incorporate AVs into their LRTPs. These recommendations are in line with the state's vision to be a leader in the field of the new transformative technologies and are synergistic with the several initiatives the state is already undertaking.

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EXECUTIVE SUMMARY

Automated Vehicles (AVs) and Connected Vehicles (CVs) are considered as one of the transformational technologies in Transportation. There is optimism that AVs can improve the safety of the transportation system, reduce congestion, increase reliability, offer improved mobility solutions to all segments of the population, including the transportation-disadvantaged such as the elderly and disabled, and improve the quality of life of all people. The Florida Department of Transportation (FDOT) has been actively pursuing various initiatives on all aspects of AV (policy, liability, safety, operations, planning, etc.) via its working groups, annual summits, pilot projects, and research studies.

This research study is specifically focused on the issue of incorporating AVs into the Long Range Transportation Plans (LRTPs) process undertaken by Metropolitan Planning Organizations (MPOs). As a further impetus to this issue, the recently enacted HB 7061[1] stipulates that the Long Range Transportation Plans (LRTPs) in Florida consider the infrastructure changes needed to accommodate advanced vehicle technologies such as autonomous vehicles. This is indeed historic in that it represents one of the first mandates of a state legislation that autonomous vehicles be included in long range transportation planning.

This study reviewed current LRTPs of Florida MPOs with regards to AVs. Only about one-third of all MPOs include AV-related language in their current plans and there is much variability in what is discussed. While some MPOs simply recognize the emergent technology an indicate that they are monitoring progress, others have tried to articulate possibly implications of the technology on meeting their planning goals.

This study also conducted a survey of MPOs to assess their opinions and needs. Overall, 23 of the 27 MPOs had provided responses (there are 21 survey responses as Bay County, Florida-Alabama, and Okaloosa-Walton TPOs are a part of the West Florida Regional Planning Council (WFRPC) and have the same contact person).

The first question examined the perception of the MPOs towards the impact of AV technology on achieving their planning goals. Practically all MPOs felt that AV/CV (technologies would have a positive impact on attaining mobility and highway safety goals. A very large proportion of the MPOs also felt that this technology will have a positive impact on reliability, capacity, and livability goals although a good number of them also indicated that they were unsure about the possible impact. Many MPOs indicated that they were unsure about the impacts of AV/CV on attaining pedestrian safety and economic growth goals. In fact, in the case of economic growth, more MPOs were unsure of the impact than those that indicated a positive impact. It is also important to note that few responses indicated a negative impact of AV/CV on planning goals – those that did not perceive a positive impact of the technology were more likely to be unsure of its impact than to indicate a negative impact.

The second question posed to the MPOs was "What would you need to know/have to make an informed decision on when and how to incorporate AV/CV in the LRTP of your region?" Eight items were provided, and the respondents were asked to indicate "Yes, this is needed", "No, we know the answer", or "No, this is not critical". Quite interestingly, the MPOs were almost unanimous (19 or more out of 21) in indicating that five of the eight items listed were needed.

[1] §239, Fl. Stat. (2016). http://laws.flrules.org/2016/239

Specifically, the MPOs need a process for dealing with the large amount of uncertainty associated with the AV technology, plausible set of AV/CV scenarios to plan for, insights into timelines for availability and adoption of these technologies, and information on the potential impacts of these technologies on travel demand patterns. About 24% of the respondents felt that they were aware of terminology while the remaining needed information on definitions. Some of the MPOs felt that details about state and federal policy were not needed while about 80% felt that these were needed. Finally, the only item in the list that MPOs felt to be non-critical (33%) was information on public perceptions about this technology.

The last question was aimed at collecting some insights into how MPOs are advancing their models to accommodate technologies that are already in the market place though not extensively. Specifically, the following question was asked: "Are you considering incorporating any of these in your travel demand models for the next LRTP study?" The responses could be "Yes", "No" or "Maybe Later". A majority of the MPOs are already incorporating real-time travel information into their models. However, less than 50% of the MPOs have incorporated electric vehicles, car sharing systems, and ride sharing systems. It is useful to acknowledge that the actual extent to which each of these are incorporated into the models can vary. Among those that have not, more MPOs indicated that they might consider it later than those that indicated that they do not accommodate these.

The survey responses indicate that while MPOs are not skeptical of AV, there is much uncertainty in the anticipated impacts of this technology on attaining their planning goals. Further, the surveys clearly point to the MPOs need for information. This study undertook a synthesis of literature to address these issues and these are included in the final report.

Finally, recommendations are developed for FDOT considering the legislative mandate in Florida to explicitly consider such technologies in the planning process, the limited attention to AV/CV in the existing MPO plans, the MPOs' clearly stated need for information and direction, substantial magnitudes of uncertainty associated with the technology, and the lack of any externally recommended processes. The following are the recommendations (these are discussed in detail along with the roles and responsibilities of various entities in the final report):

(1) Define organizational roles and responsibilities, establish leadership, engage new stakeholders, and support a continuous program to facilitate efficient transition to new practices

(2) Establish a program of continuing education and knowledge sharing focused on planning implications of AV/CV

(3) Assist MPOs to explicitly include AV/CV in their plans

(4) Undertake scenario planning exercises

(5) Undertake exploratory modeling/forecasting exercises and use pilot studies to inform enhancement of forecasting models.

(6) Start data collection initiatives to monitor emergent trends in technology/services adoption and shifts in travel behavior patterns

(7) Establish potential "dates of decision" for making policy changes to planning/forecasting procedures

These recommendations are in line with the state's vision to be a leader in the field of the new transformative technologies and are synergistic with the several initiatives the state is already undertaking.

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CHAPTER 1:
INTRODUCTION

Automated Vehicles (AVs) are considered as one of the transformational technologies in transportation[1]. There is s optimism that AVs can improve the safety of the transportation system, reduce congestion, increase reliability, offer improved mobility solutions to all segments of the population including the transportation-disadvantaged such as the elderly and disabled, and improve the quality of life of all people. The Florida Department of Transportation (FDOT) has been actively pursuing various initiatives on all aspects of AV (policy, liability, safety, operations, planning, etc.) via its working groups, annual summits, pilot projects, and research studies[2]. This research study is specifically focused on the issue of incorporating AVs in Long Range Transportation Plans (LRTPs).

This study is motivated by the observation that there is extremely limited incorporation of AVs into the Long Range Transportation Planning (LRTP) process undertaken by Metropolitan Planning Organizations (MPOs). Arguably, a key reason for this is that AVs are not yet in the traffic stream, and there is much uncertainty associated with the times lines for development of technology, user adoption, and market penetration rates. However, LRTPs have a 25 year time horizon for planning, which is a significant amount of time for the AV technology to mature and be adopted extensively. Therefore, there is a need for MPOs to start thinking about incorporating AVs into their LRTPs now[3]. A review of literature clearly indicates that research on understanding the travel behavior impacts of AV are in their infancy, and much needs to be done in the process of incorporating AVs effectively into forecasting models. A survey of Florida MPOs (discussed in detail in Chapter 3) also highlights an overwhelming need by MPOs for information and direction.

As a further impetus to this issue, the recently enacted HB 7061 stipulates that the Long Range Transportation Plans (LRTPs) in Florida consider the infrastructure changes needed to accommodate advanced vehicle technologies such as autonomous vehicles. This is indeed historic in that it represents one of the first mandates of a state legislation that autonomous vehicles be included in long range transportation planning[4] (See Appendix 7 for further details). This bill also requires autonomous vehicle technology in the Strategic Intermodal Systems Plan[5]. This legislation not only mandates the consideration of autonomous vehicles (for both passenger and freight transportation) for transportation planning but also facilitates the active testing of such technology within the state.

Overall, the current state may be described by the legislative mandate in Florida to explicitly consider such technologies in the planning process, the limited attention to AV/CV in the existing MPO plans, the MPOs' clearly stated need for information and direction, significant magnitudes of uncertainty associated with the technology, and the lack of any externally recommended processes. The ultimate goal of this study is to recommend an overall strategy to FDOT to help its MPOs start incorporating AVs in their LRTPs. This strategy (or a set of recommendations) is in line with the state's vision to be a leader in the field of the new

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[1] http://onlinepubs.trb.org/onlinepubs/circulars/ec208.pdf
[2] http://www.automatedfl.com/
[3] Srinivasan, S., Smith, S., Milakis, D. (2015) "Implications of Vehicle Automation for Planning", *Road Vehicle Automation 3*, G. Meyer and S. Beiker (eds.),pp 287-295 Lecture Notes in Mobility, DOI 10.1007/978-3-319-40503-2_23
[4]§239, Fl. Stat. (2016). http://laws.flrules.org/2016/239 (CHAPTER 2016-239 pp. 51-52)
[5]§239.47, Fl. Stat. (2016). http://laws.flrules.org/2016/239 (CHAPTER 2016-239 pp. 53)

transformative technologies and be synergistic with the several initiatives the state is already undertaking (and these other initiatives cover aspects beyond LRTP, which is the main focus of this study).

In the process of developing the recommendations, the study team reviewed current LRTPs of Florida MPOs with regards to AVs (discussed in Chapter 2) and conducted a survey of MPOs to assess their opinions and needs (discussed in Chapter 3). The recommendations to FDOT are presented and discussed in Chapter 4. The report also a set of appendices which serve as short synthesis documents to address concerns identified from MPO surveys.

CHAPTER 2:
AV IN CURRENT LRTPs

This chapter presents a review of the current LRTPs of all MPOs in Florida with specific focus on the incorporation of AV-related language. As indicated in Table 2.1, only about a third of MPOs have AV (or a term very closely related to AV or CV) mentioned in their plan documents. It is useful to note that mentions of Intelligent Transportation Systems (ITS) in LRTPs is not considered as a reference to AV in this synthesis table. Table 2.2 present further details about the goals of each MPO and the AV-related discussions in their plans.

Overall, there is much variation in the treatment of AV across the different plans. At the simplest level is the recognition of AV or a specific AV technology such as Advanced Driver Assistance Systems (ADAS) or MobileEye as a key emergent technology with statements that the MPO is monitoring the developments in the area. Polk county MPO's plan mentions CV and V-to-I infrastructure developments. As a further step, some MPOs such as North Florida, Pinellas, and Space Coast, discuss potential impacts of this technology on factors such as capacity, reliability, safety, and efficiency. While most plans that mention AV recognize (either implicitly or explicitly) that the technology is in its early stages of development/testing, some MPOs (like Pinellas) try to envision factors (such as cost) that could impact widespread adoption. Finally, North Florida and Space Coast MPOs also recognize that the nature of this transformational technology and the associated uncertainties could require substantial changes to the planning process.

Overall, there is limited treatment of AVs in LRTPs in Florida. Collectively, the ones that do mention AVs, provide several basic discussion items that can be added to the plans of the other MPOs. At the same time, there are shortcomings too. For example, the current plans do not have a clear and consistent definition of technologies. As is evident from Table 2.2, the current forecast year for most MPOs is 2040 and practically all MPOs are due for a plan update in the next 4-5 years. Based on the findings of this study and the insights learned from from the suggested next steps, we envision that the next plan updates of all MPOs will incorporate systematic and detailed discussions of AV in their plans.

Table 2.1 List of Florida MPOs With Summary of AV Mentions in their LRTPs

MPO	AV in LRTP (Summary)
Bay	None
Broward	None
Capital Region	None
Charlotte County – Punta Gorda	Mentions advanced technology such as ADAS and Mobileye and the possibility of freight implementations
Collier	None
Florida-Alabama	None
Gainesville	None
Hernando/Citrus	None
Hillsborough	Mentions the AV pilot project in the region
Indian River	Indicate that they will monitor advances in the new technologies
Lake Sumter	None
Lee	State AV as part of their congestion management process; indicate that they will keep track of technology advances, and mention the Tampa and Miami pilot projects
Martin	None
Orlando	None
Miami-Dade	None
North Florida	Recognizes the transformative impacts of AV technology, possible impacts on safety, congestion, and sustainability, and acknowledges the need for new planning paradigms
Ocala-Marion County	None
Okaloosa Walton	None
Palm Beach	None
Pasco	None
Pinellas	Recognize the impacts of technology on reliability and safety; acknowledge that it is in early stages of testing and development of regulations; state that cost would be a major factor in the adoption. County is monitoring FDOT's efforts in this area
Polk	Mentions Connected Vehicles and V-to-I infrastructure development in District 1
River to Sea	None
Sarasota-Manatee	None
Space Coast	Recognize impacts on capacity, efficiency, parking, costs, flexibility, etc. Highlight increased uncertainty and its impacts on the planning process. Note a "cultural shift" and envision connected communities
St Lucie	Mentions AV as a part of their Intelligent Transportation Systems but acknowledge that technology is in the research and development stage.

Table 2.2 MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Bay County TPO[1]	2040	Provide a multi-modal network of integrated transportation systems that meet the following criteria: Movement of people and goods, safety, efficient operation and maintenance, protects, preserves and enhances a high quality of life, consistent, continuing, cooperative and comprehensive planning processes, support economic vitality, secure for residents, visitors and commerce, and maintain acceptable roadway level of service on all major facilities.	2016
Broward[2]	2040	Provide a Transportation System that: move people, create jobs, and strengthen communities.	2019
Capital Region TPA[3]	2040	A multimodal transportation system that promotes economic vitality and quality of life throughout the region by enforcing: connectivity, economic development, access, multimodalism, land use, security, safety, public health, and natural resource protection/conservation	2019

[1] http://www.wfrpc.org/programs/b-tpo/lrtp
[2] http://www.browardmpo.org/index.php/core-products/long-range-transportation-plan-lrtp
[3] http://www.crtpa.org/connections-2040.html

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Charlotte County-Punta Gorda[1]	2040	1. Ensure efficient travel for all modes of transportation 2. Expand transportation choices for everyone 3. Preserve natural spaces while promoting a healthy community 4. Promote vibrant centers and the local economy 5. Enhance safety and security for everyone. **About AV/CV:** The plan does not mention anything about the automated vehicles, but they talk about how technology is advancing rapidly and they mention some example of up to date technology like: Advanced Driver Assistance Systems, GeoTab (data collection device) and MobilEye (devices that assist the driver with daylight bicycles and pedestrian collision warnings). They also talk about implementing this technology in Miami for a pilot project of freight delivery.	2020
Collier County[2]	2040	1. Ensure the security of transportation system for users 2. Protect environmental resources 3. Improve system continuity and connectivity 4. Reduce roadway congestion 5. Promote freight movement 6. Increase the safety of the transportation system for users 7. Promote Multi-modal solutions 8. Promote the integrated planning of transportation and land use	2017-2020
Florida-Alabama TPO[3]	2040	Provide a transportation system that meet the following criteria: safety and security, meets user needs, efficient maintenance and operation, multimodal, integrated and connected, support economic vitality and high quality of life respectful of the environment, public health and vulnerable users, consistent, continuing, cooperative and comprehensive planning processes.	2020

[1] http://ccmpo.com/joomla4/index.php?option=com_content&view=article&id=8&Itemid=112&lang=en
[2] http://www.colliermpo.com/index.aspx?page=187
[3] http://www.wfrpc.org/programs/fl-al-tpo/long-range-plan

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Gainesville MTPO[1]	2040	1. Support economic vitality 2. Increase safety and security for motorized and no-motorized users 3. Increase the accessibility and mobility of people and freight 4. Protect and enhance the environment, promote energy conservation, improve the quality of life and promote consistency between transportation improvements and State and local planned growth and economic pattern 5. Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight 6. Promote efficient system management and operation 7. Emphasize the preservation of the existing transportation system	2020
Hernando /Citrus[2]	2040	1. Support the development of the county's economy and manage growth through the development of financially-feasible multimodal facilities and services and affordable growth strategies 2. Increase the safety and security of the county's transportation system 3. Provide for the mobility needs of the county's population and economy by providing safe, secure, effective, and efficient movement of people and goods 4. Support the efficient, safe, and secure integration of port, airport, and rail modes of transportation and associated intermodal facilities into one cohesive intermodal system 5. Preserve, where possible, and enhance community social and environmental values	2020

[1] http://www.ncfrpc.org/mtpo/LRTP.html
[2] http://www.hernandocitrusmpo.us/

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Hillsborough County[1]	2040	1. Enhance the safety and security of the transportation system for both motorized and non-motorized users 2. Support economic vitality to foster the global competitiveness, productivity and efficiency of local and regional businesses 3. Improve the quality of life, promote energy conservation and enhance the environment, while minimizing transportation-related fuel consumption, air pollution and greenhouse gas emissions 4. Promote accessibility and mobility by increasing and improving multi-modal transportation choices, and the connectivity across and between modes, for people and freight 5. Assure that transportation improvements coordinate closely with comprehensive land use plans and support anticipated growth and development patterns 6. Consider cost-effective solutions that preserve existing facilities and optimize the efficiency of Transportation System Management and operations	2019
		About AC/CV: The plan mentions that the Tampa-Hillsborough Expressway Authority has conducted a Bus Toll Lanes Study and an Automated Vehicles Pilot Project. The Hillsborough County Aviation Authority has recently completed an update to the Tampa International Airport Master Plan and the Port Tampa Bay Strategic Plan is the long range planning document for Port Tampa Bay.	

[1] http://www.planhillsborough.org/2040-lrtp/

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Indian River County[1]	2040	1. A connected, responsive, aesthetically pleasing, and efficient transportation system that meets the needs of Indian River County residents, visitors, and businesses 2. A transportation system that provides travel alternatives which enhance mobility for people and freight 3. A transportation system that is sensitive to the natural and social environment 4. A safe transportation system for Indian County residents, visitors, and businesses 5. A transportation system that is preserved and maintained through adequate investment and management of the infrastructure **About AV/CV:** The plan mentions that the Indian River County will monitor the potential advancement of Connected Vehicle and Autonomous Vehicles technologies. They recognize the present of new technology advances as potential solutions and they affirm they will monitor these technologies for the long range transportation plan of Indian River county.	2020
Lake-Sumter[2]	2040	1. Investing in transportation to support a prosperous, competitive regional economy 2. Providing a safe and secure transportation system or all users 3. Proactively managing the operations of the regionally significant transportation facilities in the MPO planning area for all users 4. Improving mobility options and connectivity for people and goods 5. Making transportation decisions that support communities' visions and promote responsible social, economic and environmental stewardship	2020

[1] http://www.irmpo.com/LRTP/
[2] http://www.lakesumtermpo.com/documents/lrtp.aspx

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Lee County[1]	2040	Adopt a multi-modal transportation system that is: Balanced and integrated with all transportation modes for people and goods, Safe and secure for existing and future residents, visitors, and businesses, Enhances emergency responsiveness and evacuation, Sensitive to the County's communities, the community character, and environmental resources, Enhances economic growth and anticipates development demands, Maintained, optimized, and expanded using the best available technologies and innovation, Financially feasible, Coordinated with relevant agencies and based on effective integration of transportation, land use, conservation, and smart growth planning.	2020
		About AV/CV: The plan presents a section of Automated Vehicles as part of the Congestion Management Process Projects. This section talks about the existing advance technology currently used in Tampa Bay were passenger vehicles are using Advance Driver Assistance Systems like GeoTab and MobilEye devices. Also mentions the freight delivery pilot project focuses on the floral industry through Miami International Airport. There is a brief discussion about how technology is advancing rapidly and the Lee MPO mentions that they are staying up to day with changing policies and partnership opportunities. In this section they MPO indicates that the outcomes of these studies developed by the FDOT and other future opportunities have the potential to change the future of Lee County's transportation entirely. The county indicates that the necessary policies, regulations, and cooperative agreements are needed to support this innovation and determine impacts to local transportation plans. The section of Automated Vehicles ends by saying that the IHS Automotive, a global marketing group, predicted that by the year of 2030, 92 percent of the US automobile fleet will be equipped with self-driving features.	

[1] http://www.leempo.com/CollierLeeMPO.shtml

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Martin[1]	2040	1. An efficient multimodal transportation system that supports the local economy and maintains the quality of life 2. A safe multimodal transportation system 3. Protect the existing transportation system and the natural environment, minimizing adverse community impacts 4. A transportation system that addresses the needs and concerns of the public	2019-2020
MetroPlan Orlando[2]	2040	Provide a Transportation System that promotes: Safety, Balanced multi-modal system, Integrated regional system, quality of life, Efficient and cost effective, Energy and environmental stewardship, and Economic vitality.	2020-2021
Miami-Dade[3]	2040	Provide a Transportation System that: Improve system and travel, Increase safety and security, support economic vitality, Protect and preserve environment and quality of life, Enhance connectivity, Optimize sound investment strategies, and Preserve existing system.	2019

[1] https://www.martinmpo.com/documents/
[2] http://www.metroplanorlando.com/plans/long-range-transportation-plan/
[3] http://miamidadempo.org/long-range-transportation-plan.asp

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
North Florida TPO[1]	2040	1. Invest in projects that enhance economic competitiveness 2. Invest in livable and sustainable communities 3. Enhance safety 4. Enhance mobility and accessibility 5. Enhance equity in decision making 6. Preserve and maintain our existing system	2019
		About AV/CV: The plan mentions that Autonomous and Connected Vehicles (AV/CV) will fundamentally change the way people travel, their relationship with the vehicles and the infrastructure needed to meet the mobility needs. This chapter of the plan explains how this new technology will help address some of the current problems: 1. Safer roads – new technologies in cars and on roadways will greatly reduce motor vehicle crashes in the coming decades. Some experts predict that we can virtually eliminate traffic fatalities by using these new technologies in concern with law enforcement, better engineering and education. 2. Less congestion – Automated and connected vehicles, operating in platoons or independently, will travel at high speeds and occupy less highway space, as on board sensors, vehicle-to-vehicle and vehicle-to-infrastructure communications allow for more active traffic management across and commuting corridors. 3. Greater sustainability – fewer idling, fuming cars, more efficient vehicles of all kinds, and smoother connections between transportation modes will have a highly positive impact on the environment and air quality. They indicate that these outcomes are highly desirable, and ultimately achievable. However, the path forward may require new Paradigms for transportation owners from the way they plan, to how they align resources, to how they interact with the public at large.	

[1] http://northfloridatpo.com/planning-studies/lrtp/

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Ocala /Marion County TPO[1]	2035	1. Develop and enhance a multi-modal transportation system that addresses the travel of users and facilitates the movement of freight and goods within the community as well as the central Florida region 2. Continually improve upon the safe operation of local transportation facilities 3. Ensure the transportation system has sufficient capacity to serve the anticipated growth within the planning area 4. Incorporate measures to preserve natural resources and minimize environmental impact into the transportation planning process 5. Ensure the long range transportation plans is cost feasible based upon the most current revenue estimates.	2016
Okaloosa-Walton TPO[2]	2035	Provide a transportation system that meet the following criteria: Safe, multi-modal network that is user-friendly and maximizes mobility, Effective movement of goods and people in order to increase the region's competitiveness and grow the economy, Promote sustainability and environmental protection, Promote a high quality of life by protecting community features, supporting the public, and marrying transportation planning with land use planning. Make improvements to the transportation system economically in order to optimize dollars spent and the efficiency of existing transportation facilities. Provide a cooperative, continuing, and comprehensive transportation planning process. Enhance the safety and security of the transportation system.	2017
Palm Beach[3]	2040	1. Provide an efficient and reliable vehicular transportation system 2. Prioritize an efficient and interconnected mass transit system 3. Prioritize a safe and convenient non-motorized transportation network 4. Maximize the efficient movement of freight through the region 5. Preserve and enhance social and environmental resources	2020

[1] http://www.ocalafl.org/tpo/TPO.aspx?id=664
[2] http://www.wfrpc.org/programs/o-w-tpo/long-range-plan
[3] http://www.palmbeachmpo.org/LRTP

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Pasco County[1]	2040	1. Support Economic Development 2. Improve Safety and Security 3. Provide local and Regional Connectivity and Transportation Choices 4. Create Quality Places 5. Provide a Reliable and Efficient Multimodal Transportation System 6. Encourage Public Participation.	2020
Pinellas County[2]	2040	1. Support and further economic development 2. Provide a balanced and integrated multi-modal transportation system for local and regional travel 3. Provide for a safe and secure transportation system for all users 4. Provide for, manage and operate an efficient transportation system 5. Encourage public participation and ensure that the transportation plan and other MPO planning activities reflect the needs of the community, particularly those that are traditionally underserved 6. Enhance quality of life and promote sustainability **About AV/CV:** The plan mentions that future technology is being developed today like the Autonomous vehicles that has the ability to increase travel reliability and safety. They also explain that even that Autonomous or Self-Driving Vehicles are being tested for eventual private use and they are still regulatory and legislative hurdles to overcome, markets experts speculate that fully autonomous vehicles could be available for purchase around 2020. The LRTP also mentions that Autonomous Vehicles could create a driving or commuting atmosphere which provides time savings by allowing drivers to complete other tasks while they would otherwise have been navigating the wheel. Finally, they talk about the cost of these vehicles which will likely hinder widespread ownership in the early years of their availability to the public. They mention that these technologies have challenges to overcome and through an annual statewide summit, Pinellas County is following the research and projects developed by the FDOT in order to determine the factors that will affect future travel demand and needs in the county	2019

[1] http://www.pascocountyfl.net/index.aspx?nid=2302
[2] http://forwardpinellas.org/guiding-plans/2040-long-range-transportation-plan/

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO	Forecast Year	Major Goals and AV Mention	Next Update
Polk TPO[1]	2040	Develop and maintain an integrated multi-modal transportation system to provide safe travel for all users, the efficient movement of goods and services, and to promote livable communities and economic activity. The Polk transportation system should meet the following requirements: mobility, safety, sustainable resources, economy, and livability.	2020
		About AV/CV: The plan mentions Connected Vehicles as one of the long term planned project. They indicate that this project would deploy Vehicle to Infrastructure (V2I) equipment in FDOT District 1.	
River to Sea TPO[2]	2040	1. Provide a Balanced and Efficient Multimodal Transportation System 2. Support Economic Development 3. Enhance Connectivity and Transportation Choices 4. Improve Safety and Security 5. Continue to Provide and Create New Quality Places 6. Provide Transportation Equity and Encourage Public Participation	2020
Sarasota /Manatee[3]	2040	1. Improve the safety and security of the transportation system for all users 2. Improve accessibility and multi-modal connectivity by promoting proximity to jobs and efficient movement of freight and goods 3. Promote economic vitality and viability through regional coordination of intermodal system 4. Improve management, operations and coordination to promote an efficient transportation system locally and regionally 5. Improve environmental sustainability and community livability in coordination with local government comprehensive plans.	2020

[1] http://www.polktpo.com/2040-lrtp.aspx
[2] http://www.r2cmobility2040.com/Documents-6-19.html
[3] https://www.mympo.org/2040-long-range-transportation-plan

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO's	Forecast Year	Major Goals and AV Mention	Next Update
Space Coast TPO[1]	2040	1. Enhance economic development through intermodal transportation connections 2. Increase the range of community, housing and travel options 3. Balance preservation of the natural environment with economic development and livability **About AV/CV:** The plan talks about Autonomous Vehicles (AV) at the section of "Need for a culture shift". They present AV as one of the reason why the Long Range Transportation Plans should be updated every five years. The plan explains that the unknown impact of changing technologies makes necessarily to update the LRTP. The LRTP also indicates that AV will increase roadway efficiency, double roadway capacities, provide flexibility in vehicle use, lower transit operation costs and improve parking and land use efficiencies. The will change the parking structure, rather than in front of buildings, parking will locate on the fringe of hubs as cars park themselves. Despite the higher capacities and simplified parking, changes in lifestyle preferences, including an emphasis on personal and environmental health, will foster walkable hubs and neighborhoods. They present a small plan that includes illustrations of the potential future developments expected in the year of 2060. These future developments use AV to connect the communities providing services and employment centers within walking distance of residential neighborhoods.	2020

[1] http://www.spacecoast2040.com/plan-progress---work-products.html

Table 2.2 (Continued) MPO Goals and AV Discussion in LRTPs

MPO's	Forecast Year	Major Goals and AV Mention	Next Update
St. Lucie TPO[1]	2040	1. Provide for efficient transportation that serves local and regional needs and stimulates economic prosperity and growth 2. Ensure transportation choices for all residents, visitors, and businesses 3. Maintain the condition and improve the efficiency of transportation assets and services 4. Improve land use and transportation decision-making through community participation and intergovernmental cooperation 5. Protect and enhance public health and the environment 6. Provide safer and more secure transportation.	2020
		About AV/CV: The LRTP talks about the Automated Vehicles (AV) as part of the future of Intelligent Transportation Systems. The plan only mentions that research and developments of the government and private sectors are being conducted in the area of automated vehicles. An example of these developments are technologies such as collision-avoidance, in which the vehicle senses an impending crash and applies the brakes.	

[1] http://www.stlucietpo.org/

CHAPTER 3:
SURVEY OF FLORIDA MPOS

This chapter synthesizes the findings from a survey of Florida's MPOs on their perceptions about the potential impacts of AV technology and their current needs as they prepare to incorporate this into their Long Range Transportation Planning process. The survey was administered via e-mail to the staff directors of the MPOs obtained from the MPOAC website. FDOT central office and the chair of the MPOAC provided support with the survey administration and follow up. A copy of the survey instrument is presented in Appendix 1. Overall, 23 of the 27 MPOs had provided responses (There are 21 survey responses as Bay County, Florida-Alabama, and Okaloosa-Walton TPOs are a part of the WFRPC and have the same contact person; Appendix 1 also identifies the MPOs that did respond). In the rest of this chapter we present a summary of findings from this survey.

The first question examined the perception of the MPOs towards the impact of AV technology on achieving their planning goals. The following question was asked "How do you think AV/CV technologies will impact the attainment of planning goals of your region?" Seven broad planning goals (Capacity (Congestion Management), Reliability, Livability, Mobility, Economic Growth, Highway Safety, Pedestrian/Bicycle Safety) were listed and for each, the possible responses include "positive impact", "negative impact", "not sure" and "not applicable". Tables 3.1 and 3.2 summarize the results (Table 3.1 presents the number of responses and Table 3.2 presents the Percentage of responses). The planning goals are sorted in the decreasing order of positive impact by AV technology.

Practically all MPOs felt that AV/CV technologies would have a positive impact on attaining mobility and highway safety goals. A very large proportion of the MPOs also felt that this technology will have a positive impact on reliability, capacity, and livability goals although a good number of them also indicated that they were unsure about the possible impact. Many MPOs indicated that they were unsure about the impacts of AV/CV on attaining pedestrian safety and economic growth goals. In fact, in the case of economic growth, more MPOs were unsure of the impact than those that indicated a positive impact. It is also important to note that few responses indicated a negative impact of AV/CV on planning goals – Those that did not perceive a positive impact of the technology were more likely to be unsure of its impact than indicate a negative impact.

Table 3.1. Summary of Responses to Perceived Impact of AV/CV on Meeting Planning Goals

	Positively	Not Sure	Negatively	N/A
Mobility	19	1	1	
Highway Safety	19	1	1	
Reliability	16	4	1	
Capacity (Congestion Management)	14	6	1	
Livability	12	7	2	
Pedestrian/Bicycle Safety	11	9		1
Economic Growth	9	12		

Table 3.2. Summary of Responses to Perceived Impact of AV/CV on Meeting Planning Goals (Percentages)

	Positively	Not Sure	Negatively	N/A
Mobility	90.48	4.76	4.76	0.00
Highway Safety	90.48	4.76	4.76	0.00
Reliability	76.19	19.05	4.76	0.00
Capacity (Congestion Management)	66.67	28.57	4.76	0.00
Livability	57.14	33.33	9.52	0.00
Pedestrian/Bicycle Safety	52.38	42.86	0.00	4.76
Economic Growth	42.86	57.14	0.00	0.00

In addition, the MPOs were allowed to add additional planning goals and indicate one of the four possible outcomes for each. Only four respondents used this option. This open-ended part of the survey indicates that MPOs were unsure about the impacts of AV on accessibility, security, and law enforcement (1 response each). One agency also indicated a positive impact on public transportation.

The second question posed to the MPOs was "What would you need to know/have to make an informed decision on when and how to incorporate AV/CV in the LRTP of your region?" Eight items were provided and the respondents were asked to indicate "Yes, this is needed", "No, we know the answer", or "No, this is not critical". Tables 3.3 and 3.4 summarize the results (Table 3.3 presents the number of responses and Table 3.4 presents the Percentage of responses). The items are sorted in the decreasing order of need (decreasing percentages for "Yes, this is needed").

Table 3.3. Summary of Responses to MPO Needs

	Yes, this is needed	No, we know the answer	No, this is not critical
Potential impacts on travel demand patterns	20		1
A plausible list of AV/CV scenarios to plan for	20		1
Timeline(s) of availability of various technologies	19	1	1
Adoption timeline(s) of various technologies	19		2
A systematic process for planning for uncertain but transformative developments	19		2
Clear definitions of various technologies	16	5	
State / Federal policy related AV/CV	17	1	3
Public perception about AV/CV technologies	11	3	7

Table 3.4. Summary of Responses to MPO Needs (Percentages)

	Yes, this is needed	No, we know the answer	No, this is not critical
Potential impacts on travel demand patterns	95.24	0.00	4.76
A plausible list of AV/CV scenarios to plan for	95.24	0.00	4.76
Timeline(s) of availability of various technologies	90.48	4.76	4.76
Adoption timeline(s) of various technologies	90.48	0.00	9.52
A systematic process for planning for uncertain but transformative developments	90.48	0.00	9.52
Clear definitions of various technologies	76.19	23.81	0.00
State / Federal policy related AV/CV	80.95	4.76	14.29
Public perception about AV/CV technologies	52.38	14.29	33.33

Quite interestingly, the MPOs were almost unanimous (19 or more out of 21) in indicating that five of the eight items listed were needed. Specifically, the MPOs need a process for dealing with the large amount of uncertainty associated with the AV technology, plausible set of AV/CV scenarios to plan for, insights into timelines for availability and adoption of these technologies, and information on the potential impacts of these technologies on travel demand patterns. About 24% of the respondents felt that they were aware of terminology while the remaining needed information on definitions. Some of the MPOs felt that details about state and federal policy is not needed while about 80% felt that this was needed. Finally, the only item in the list that MPOs felt to be non-critical (33%) was information on public perceptions about this technology.

In addition the MPOs were allowed to add needs. Nine responses were obtained to this open ended question (all "yes, this is needed"). These are (MPOs were allowed to provide multiple additional needs):

- Funding Sources and Private-Public-Partnerships
- Cost of technology (to government and private)
- Recommended investment strategies for local infrastructure
- Infrastructure needs and costs
- Local agency liability responsibility
- Operational impacts and benefits (measurable)
- Addressing Privacy Concerns
- System architecture (Cloud, SRDC, etc.)
- Architecture like the Intelligent Transportation Systems (ITS) Architecture that we can start incorporating designs into

The above responses indicate that cost is a significant additional concern to the MPOs. In addition MPOs are also concerned about liability, privacy concerns, and ways of quantifying the benefits. Finally, a desire for a systems architecture was also expressed.

The last question was aimed at collecting some insights into how MPOs are advancing their models to accommodate technologies that are already in the market place though not extensively. Specifically, the following question was asked: "Are you considering incorporating any of these in your travel demand models for the next LRTP study?" The responses could be "Yes", "No" or "Maybe Later". Tables 3.5 and 3.6 summarize the results (Table 3.5 presents the number of responses and Table 3.6 presents the Percentage of responses).

Table 3.5. Summary of Responses to Model Updates

	Yes	No	Maybe later
Real time traveler information	13	3	5
Electric vehicles and locations of charging stations	8	5	8
Ride Sharing Systems (like Uber)	7	5	9
Car Sharing Systems (like Zipcar)	5	6	10

Table 3.6. Summary of Responses to Model Updates (Percentages)

	Yes	No	Maybe later
Real time traveler information	61.90	14.29	23.81
Electric vehicles and locations of charging stations	38.10	23.81	38.10
Ride Sharing Systems (like Uber)	33.33	23.81	42.86
Car Sharing Systems (like Zipcar)	23.81	28.57	47.62

A majority of the MPOs are already incorporating real-time travel information into their models. However, less than 50% of the MPOs have incorporated electric vehicles, car sharing systems, and ride sharing systems. It is useful to acknowledge that the actual extent to which each of these are incorporated into the models can vary. Among those that have not, more MPOs indicated that they might consider it later than those that indicated that they do not accommodate these. Incorporation of these technologies into the current models can be a useful intermediate step towards updating models to deal with AVs. This issue is also discussed further in the recommendations.

The survey responses indicate that while MPOs are not skeptical of AV, there is much uncertainty in the anticipated impacts of this technology in attaining their planning goals. Further, the surveys clearly point to the MPOs need for information. This study undertook a synthesis of literature to address these issues and these are presented as a series of appendices.

- Appendix 2 presents a summary of the promises and challenges of the AV technology in addressing the goals identified in the Florida Transportation Plan[1]. This discussion is aimed at providing a baseline against which the MPOs can evaluate the impacts of AV on their own goals.
- Appendix 3 is focused on terminology. An extensive discussion of inconsistencies in the literature related to the use of terms such as "automated vehicle", "autonomous vehicle", and "connected vehicle" is presented.
- Appendix 4 is focused on AV scenarios and pathways to the future. A broad overview of scenario planning studies is presented with focus on descriptions of AV scenarios developed.
- Appendix 5 presents a discussion on user perceptions and adoption of AV drawn from several consumer surveys.
- Appendix 6 presents a discussion on implications of AV on travel demand and system performance.
- Appendix 7 summarizes the Florida legislation on AVs in transportation planning.

[1] http://floridatransportationplan.com/

CHAPTER 4: RECOMMENDATIONS

The study conducted a survey of all Florida MPOs to assess their perceptions and preparedness for incorporating AV/CV in planning. The MPOs were generally favorable towards the technology and a majority indicated that AVs be beneficial to achieve their planning goals (very few indicated they anticipated negative impacts of the technology on attaining planning goals). At the same time, the number of respondents indicating that they were "not sure" about the implications also points to continued presence of uncertainty. A survey of planners[1] in about 15 major MPOs across the entire country conducted in 2014 also notes that "skepticism" is not the major factor resulting in limited attention of AVs in LRTPs; rather it is the "uncertainty" associated with the technology, its adoption, and its impacts. Our survey also overwhelmingly indicates that MPOs are looking for a lot of direction as they figure out ways to incorporate AV/CV into their forecasting and planning procedures.

An extensive review of the current Long Range Transportation Plans of all MPOs in Florida indicates that the AV/CV technology currently sees limited attention. A review[1] of the LRTPs of 25 major MPOs across the entire country in 2014 also reports scant mentions of AV in their LRTPs. Overall, the transportation planning profession, in general, is in its early stages of dealing with the impacts of the disruptions caused by AV/CV technology to its practices and methods. The current state may therefore be described by the legislative mandate in Florida to explicitly consider such technologies in the planning process, the limited attention to AV/CV in the existing MPO plans, the MPOs' clearly stated need for information and direction, significant magnitudes of uncertainty associated with the technology, and the lack of any externally recommended processes.

In this context, the study team presents a set of seven recommendations to Florida DOT as a systematic procedure for helping the state MPOs to start incorporating AV/CV in their planning process. These recommendations are in line with the state's vision to be a leader in the field of the new transformative technologies and are synergistic with the several initiatives the state is already undertaking (and these other initiatives cover aspects beyond LRTP, which is the main focus of this study). The recommendations are summarized in Table 4.1 with the identification of roles and responsibilities of different entities. This is followed by a detailed discussion of each recommendation.

[1] Guerra E (2015) "Planning for cars that drive themselves: Metropolitan Planning Organizations, regional transportation plans, and autonomous vehicles", presented at the TRB Annual Meeting in 2015

Table 4.1 Summary of Recommendations and Roles and Responsibilities of Various Entities

Recommendation	FDOT Central Office	FAV Policy Working Group	MPOAC	MTF	Consultants	Universities
Define organizational roles and responsibilities, establish leadership, engage new stakeholders, and support a continuous program to facilitate efficient transition to new practices	establish and provide programmatic support	engage non-traditional stakeholders	participate in and support central office			
Establish a program of continuing education and knowledge sharing focused on planning implications of AV/CV	administrative support	involve new stakeholders in training	organize AV update and knowledge sharing sessions at meetings / webinars		develop and deliver AV update presentations	
Assist MPOs to explicitly include AV/CV in their plans	provide direction to MPOs	formalize terminology for AV planning	facilitate coordination and support small MPOs	facilitate knowledge sharing and assist smaller MPOs	administrative and technical support to MPOs	develop definitions

Table 4.1 (Continued) Summary of Recommendations and Roles and Responsibilities of Various Entities

<table>
<tr><th>Recommendation</th><th>FDOT Central Office</th><th>FAV Policy Working Group</th><th>MPOAC</th><th>MTF</th><th>Consultants</th><th>Universities</th></tr>
<tr><td>Undertake scenario planning exercises</td><td>administrative support</td><td>liaison to new stakeholders</td><td colspan="2">facilitate knowledge sharing</td><td colspan="2">assist large MPOs with their own scenario planning exercises</td></tr>
<tr><td>Undertake exploratory modeling/forecasting exercises and use pilot studies to inform enhancement of forecasting models.</td><td>liaison between FDOT pilot studies and the modeling efforts</td><td></td><td>facilitate knowledge sharing</td><td>identify and prioritize modeling studies to be undertaken</td><td colspan="2">support large MPOs with exploratory modeling exercises</td></tr>
<tr><td>Start data collection initiatives to monitor emergent trends in technology/services adoption and shifts in travel behavior patterns</td><td>initiate data collection programs</td><td></td><td colspan="2">identify key data collection efforts needed and potential sources of funding</td><td colspan="2">collect and analyze data</td></tr>
<tr><td>Establish potential “dates of decision” for making policy changes to planning/forecasting procedures</td><td>establish dates of decisions</td><td></td><td colspan="2">discuss and identify the dates of decision for pilot studies and procedural changes</td><td></td><td></td></tr>
</table>

(1) Define organizational roles and responsibilities, establish leadership, engage new stakeholders, and support a continuous program to facilitate efficient transition to new practices

Florida has a history of standardized modeling practices for the state (The FSUTMS). In line with this philosophy, the focus of this study is on addressing transitioning modeling practices for the entire state while recognizing the differences among the various MPOs. Several entities such as the FDOT central office, the MPOs, the MPOAC, and the Model Task Force (MTF) should be appropriately included and their strengths leveraged in the transition process. These organizations are supported by consultants, software vendors, and educational institutions in the planning/forecasting process and so they join as important entities as well. Given these diverse entities, there is a clear need for FDOT to identify the relative roles and responsibilities. In discussing the various recommendations, we identify how each of these entities can assist (see also Table 4.1) and these discussions can be used to develop the framework of relationships and leadership that will guide the process of transitioning to a potentially new FSUTMS framework of the future.

The new technologies introduce several "non-traditional" stakeholders including developers of new technologies and services, private repositories of important data, futurists, and behavioral modelers. It is critical to engage these people in the development of the new modeling procedures. The Florida Automated Vehicles (FAV) working groups can serve as a liaison between entities directly in charge of forecasting and planning and the world of new and emergent stake holders.

As already indicated, the transportation planning profession is in its early stages of dealing with the impacts of AV/CV on forecasting/planning and, consequently, its impacts on procedures and models that have been long established as standards. The new technologies also bring with them significantly greater amounts of uncertainty and associated risks/rewards. Consequently, the transition process will not be short and will benefit substantially from a continuous support program established by the FDOT, which includes all entities and stakeholders already discussed.

(2) Establish a program of continuing education and knowledge sharing focused on planning implications of AV/CV

The surveys clearly established that MPOs are looking for a lot of details in preparation for their efforts to start incorporating AV/CV more explicitly in their planning processes. This study presents synthesis documents (see appendices) that address the issues of interest to MPOs. These can be used to develop initial training material (power point presentations) to provide MPOs with baseline (current-day) knowledge on these issues. In addition to sharing these as reference reading material, presentations can be scheduled to be made at upcoming MPOAC meetings, Statewide MTF meetings, and the Annual FAV Summit. In addition, webinars can be organized for staff who are unable to travel to these meetings. The planning-focused webinars/presentations recommended here are envisioned to complement other broader courses that FDOT is already planning on developing. It is also useful to mention here an FHWA study[1] that identifies skills and expertise required to incorporate CVs into transportation planning via a variety of courses aimed at different audiences. This would serve as a useful framework for developing Florida's program.

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[1] http://ntl.bts.gov/lib/59000/59100/59173/FHWA-JPO-16-364.pdf

It is also very important to emphasize that the developments in AV field are quite dynamic and, therefore, there is a need for a program of continuous education and knowledge transfer. The MPOAC and the MTF can take the initiative of including AV updates as a recurring session in their future meetings. These AV updates should initially focus on all the issues of importance as identified by the surveys and subsequently be modified to refocus based on feedbacks from MPOs. The updates should include material from private sector, federal (FHWA/Volpe center/NCHRP) initiatives, scenario planning and modeling results from peer agencies, new data collection efforts, and research studies. While those following AV developments may already be subscribing to various newsletters / discussion forums, it is important to note that most of these report/discuss all aspects of AV. Therefore, additional effort is need to extract out planning-oriented developments and insights. Consultants and university researchers can play a key role in developing and delivering these updates. The FAV working groups can facilitate bringing in additional stakeholders to provide updates

The MTF meetings have long been used as a forum for showcasing and discussing model advances in different parts of the state, and this can continue in the context of modeling AV as well.

(3) Assist MPOs to explicitly include AV/CV in their plans

A first step in the process towards incorporating AV/CV in the planning models and processes it to explicitly recognize the technology and its potential in the MPO vision plans. A survey of current LRTP documents indicates that only few MPOs mention AVs in their plans. Given the legislative mandate, FDOT should assist MPOs to develop language about AVs that can be incorporated into their plan documents. There are two key issues in this regard.

> First, there is a need for clear definitions and consistent use of terminology. As has been established in this study, use of non-equivalent terms interchangeably (such as autonomous vehicle and automated vehicle) is common in the literature. The SAE definitions of automation may be used as the standard (The NHTSA definitions are subsumed in the SAE categories). In this context, it is useful to note that connectivity is neither necessary nor sufficient for automation although transportation planners are faced with the task of incorporating both AV and CV technologies into their planning process. Therefore, there is a need to look beyond SAE/NHTSA for definitions. The results from this study can be used by the FAV policy working group (in conjunction with their own work[1]) to develop a set of terms and definitions suitable for planning documents.
>
> Second, there should be a distinction between large (Miami, Orlando Tampa, and Jacksonville areas for the purposes of this document) and small (all other regions) MPOs. Larger MPOs are likely to see more immediate and multi-modal (cars, trucks, transit) impacts of the AV/CV technology and should therefore seek to develop their own visions considering local context. On the other hand smaller MPOs may choose to keep their discussions simplistic and develop language with assistance from MPOAC and the MTF.

In either case (large and small MPOs) it is vital that AVs are not merely mentioned as "buzz

[1] http://www.automatedfl.com/wp-content/uploads/2016/02/Policy-WG-White-Paper.pdf

words"; rather there should be reasonable discussion of the anticipated /plausible impacts of AV on achieving the stated goals of the region while recognizing the challenges.

The long range transportation planning is one of several planning processes undertaken by state/local agencies. As AVs get represented within LRTPs, it is also important to ensure coordination between the LRTP and other state and local planning programs and processes to ensure consistency in the overall vision. For example there might be increased relationships between ITS plans and LRTPs. A recent FHWA[1] study provides further discussions on possible inter-relationships among the different planning processes and this can be used to guide coordination efforts in Florida.

(4) Undertake scenario planning exercises

Transportation planners have always undertaken travel demand forecasting while recognizing that uncertainties exist. However, it can be argued that the magnitude of uncertainty and the associated risks and rewards introduced by the AV/CV technology is significantly large. In the face of such large uncertainties, planning for an "expected" or a "most likely" future does not seem appropriate. A recent FHWA[2] study reports the following as a key finding "*Long-range planning activities may shift to development of "alternative futures" that make different assumptions about technologies, market adoption, and impacts on the transportation system. These assumptions would then be reviewed on a regular basis and the long-range plan modified based on actual developments.*"

Therefore, there is increased need to adopt a systematic process that explicitly addresses uncertainties (sometimes not even quantifiable) and in this context, the scenario planning approach is important. This study presents a brief overview of the processes and scenarios developed in the context of AV/CV. Using these as guidelines, this study recommends that Florida MPOs undertake their own scenario planning exercises. The large MPOs should undertake their own studies explicitly considering their local context while the smaller MPOs may undertake a pooled study of visioning and scenario planning.

This process should involve the new stakeholders who have been identified in the context of AVs (the FAV policy working group can help here) and these planning exercises be conducted locally at the large MPOs and perhaps at MPOAC/MTF/Florida AV summit meetings for the smaller MPOs (A visioning study was held at the previous FAV summit[3]). Consultants and university researchers can facilitate the process.

The process must not be restricted to visioning a future of fully automated vehicles operating everywhere. Consideration of mixed-traffic conditions (vehicles with different levels of automation) and limited locations where they can operate (say freeways / major urban highways) would be beneficial. The scenario planning exercise must consider the AV/CV technologies within the context of other mega-trends such as growth in shared mobility options, increased availability

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[1] http://ntl.bts.gov/lib/55000/55700/55711/FHWA-JPO-16-246.pdf
[2] http://ntl.bts.gov/lib/55000/55700/55711/FHWA-JPO-16-246.pdf
[3] http://www.floridaplanning.org/wp-content/uploads/2016/05/Envisioning-Floridas-Future-Final-Report.pdf#http://www.floridaplanning.org/wp-content/uploads/2016/05/Envisioning-Floridas-Future-Final-Report.pdf

of real time information, ageing of the population, differences in the behavior of the millennials, and performance of the economy. The planning must also consider all modes (auto, trucks, transit). A single exercise is simply not adequate to be able to address all these issues and so a series of scenario planning exercises are expected. Finally it is important that the MPO visioning / scenario planning exercises are consistent with the state-wide visions of possible futures[1].

(5) Undertake exploratory modeling/forecasting exercises and use pilot studies to inform enhancement of forecasting models.

Although FSUTMS serves as the overarching framework for modeling/forecasting travel demand in Florida, the state does have both trip-based and activity-based models that are operational. Among activity-based models there are two model types that are currently operational in Florida (CT-RAMP in Miami and DaySim in Jacksonville and Tampa). The different models vary in their ability to accommodate AV/CV within its framework and even the advanced models cannot possibly reflect all aspects of AV/CV impacts on travel demands with relatively simpler tweaks. Further, since the technology is not available for public use, there is no data to calibrate these models to new conditions.

Few studies have been undertaken to explore the predictive performance of travel demand models by altering parameters in the model (capacity, value of travel time, etc.) that are indicative of an AV future. It is recommend that more of such exploratory studies be undertaken to try and tweak to the models to reflect futures identified in Florida's own scenario planning exercises and to examine the predicted patterns. Initially this is to be undertaken only by the large MPOs, which have the advanced models and more immediate needs. This study also synthesizes current efforts to modify existing models to address AVs. Further, an FHWA[2] study presents discussion on possible changes need to a variety of models (not just the Long Range Forecasting Models) and other federally-funded studies[3,4] on this topic may materialize in the future.

It is also important to remember that FDOT has pilot studies that are focused on the operational patterns (such as signal timing/delays, capacity) of a traffic stream comprising AVs. Results from these studies can help develop appropriate supply-side parameters to be used in the region's travel demand model. Initial exploratory exercises may not provide results that can be used immediately within models with a good level of confidence; rather, these provide insights into how the models have to be updated overall to realistically reflect the extensive impacts of AV/CV. The model updates can be both in the form of changes to the structure as well as identifying new data needs for realistic parameter estimation and calibration. These efforts can be led by the large MPOs of Florida supported by consultants and university researchers and the MTF can serve as a natural forum for information exchange and discussions.

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[1] http://floridatransportationplan.com/visionelement.html
[2] http://ntl.bts.gov/lib/55000/55700/55712/FHWA-JPO-16-247.pdf
[3] https://rns.trb.org/dproject.asp?n=40424
[4] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3824

(6) Start data collection initiatives to monitor emergent trends in technology/services adoption and shifts in travel behavior patterns

Although the data related to behavioral impacts of AV/CV are limited given that the technology is not available extensively for public consumption, there have also been other significant developments that could provide insights into studying AV/CV adoption and impacts. These include the emergence of TNCs (Transportation Network Companies, or ride sharing services) such as Uber and Lyft, vehicle sharing services (zip car, bike sharing), and the proliferation of real-time transportation information derived from various private and crowd-sourced data delivered (often for free) via a variety of apps. While there is increasing research in impacts of these trends on travel behavior patterns, current operational travel forecasting models do not consider these extensively (the Florida MPO surveys also confirm this). Arguably one of the reasons is the limited availability of data on these emergent trends from the conventional households surveys (such as the National Household Travel Surveys) used for model development. Therefore, FDOT would benefit by investing in data collection efforts that explicitly focus on the new technology and transportation trends and its impacts on travel patterns. The effort could be led by the central office and/or the major MPOs and coordinated via the MTF to ensure alternate efforts are complementary. Consultants and universities can help with data collection and analysis.

(7) Establish potential "dates of decision" for making policy changes to planning/forecasting procedures

A study[1] of several large MPOs in the nation show that AVs are "too far removed" from actual planning and investment decisions and this is one of the reasons for limited attention this technology has received with the LTRP process. This does appear to be true for Florida as well. A review of literature does indicate that even that most advanced travel demand models, today, cannot be made to forecast the wide ranging impacts of AV with minor tweaks. There is simply no data to calibrate these "tweaked" models to, and adjustments are being made based on judgments about adoption timeless and anticipated changes to parameters of models that have been calibrated to today's conditions (This is not to say the changes are made arbitrarily; there has indeed been a lot of thought behind how parameters have been changed and what "real world phenomenon" they are intended to represent). Therefore, no major changes in modeling/forecasting practices that reflects the impacts of AVs can be made today and effectively defended. However, a pathway towards making those changes in future is needed. This may be achieved in three steps

(1) Develop knowledge on the most critical/impactful/consistent changes that can be made to the planning/forecasting procedures

This knowledge development step will draw upon the MPOs' visioning and scenario planning exercises, exploratory modeling efforts undertaken both in Florida and elsewhere, new data collection efforts and related insights, and academic research on the travel behavioral implications of AV. The knowledge developed can be in a variety of forms such as learning the aspects of travel demand that are significantly impacted,

[1] Guerra E (2015) "Planning for cars that drive themselves: Metropolitan Planning Organizations, regional transportation plans, and autonomous vehicles", presented at the TRB Annual Meeting in 2015

adjustments that can be made to parameters of existing demand models (both on the demand and supply sides), and new model components that are required.

(2) Pilot testing of procedural changes to planning/forecasting

As consistent and useful patterns start emerging from the knowledge development stage, these can be translated into a set of procedural changes to the travel model and implemented with the forecasting software. MPOs can then undertake pilot testing of these revised models by applying them to real world projects and evaluate their performance against original (state of practice) models in terms of their usefulness, reasonableness, and defensibility. Multiple pilot efforts using models from different parts of the state and focused on a variety of applications are anticipated to establish the overall robustness of the changes being tested. It would be useful for the state to establish a potential "date of decision" (say 2020 or 2025 – the date to be decided with feedback from MPOs and MTF) on when these pilot testing is likely to begin. It is likely that the first set of pilot tests will be using models of large MPOs.

(3) Develop and adopt policy to change procedures for planning/forecasting

When pilot testing of procedural changes start yielding useful, reasonable, and defensible results, the state may develop and adopt policy to formally include these procedures as standard practice for the state (or initially for large MPOs). Again, it would be useful for the state to establish a potential "date of decision" (say 2025 or 2030 – the date to be decided with feedback from MPOs and MTF) on when these policy changes are likely to happen.

It is also useful to note the following about the above-process. First, it is unlikely that a one-shot application of the three steps will result in all the desired model changes. Therefore, the three steps should be viewed as continuous processes once they begin. For example, knowledge discovery will continue even after pilot testing commences and pilot testing will continue even after certain changes have been adopted as practice (perhaps to test new knowledge that has been developed from step 1). Second, the "dates of decision" provide a temporal goal to work toward; however these are not to be treated as definitive deadlines. As has been extensively mentioned, there is a lot of uncertainty and it is important for programs to be adaptable.

APPENDIX 1: SURVEY INSTRUMENT AND RESPONDENT DETAILS

Incorporating AV/CV Technologies in the Long Range Transportation Process
(AV = Automated Vehicle CV = Connected Vehicle)

Researchers from the University of Florida (PI: Siva Srinivasan) are working with FDOT's Florida Automated Vehicles (FAV) working group to identify best practices to help MPOs start incorporating AV/CV technologies into their LRTP. This short questionnaire is to assess your perceptions and to do an initial needs assessment. Your feedback is most appreciated.

Name	
Contact (E-mail)	
MPO/Agency Represented	

How do you think AV/CV technologies will impact the attainment of planning goals of your region?

	Positively	Not Sure	Negatively	N/A
Capacity (Congestion Management)				
Reliability				
Livability				
Mobility				
Economic Growth				
Highway Safety				
Pedestrian/Bicycle Safety				
Other (specify)				
Other (specify)				

What would you need to know/have to make an informed decision on when and how to incorporate AV/CV in the LRTP of your region?

	Yes, this is needed	No, we know the answer	No, this is not critical
Clear definitions of various technologies			
Timeline(s) of availability of various technologies			
Adoption timeline(s) of various technologies			
Public perception about AV/CV technologies			
Potential impacts on travel demand patterns			
A systematic process for planning for uncertain but transformative developments			
A plausible list of AV/CV scenarios to plan for			
State / Federal policy related AV/CV			
Other (Specify)			
Other (Specify)			

Are you considering incorporating any of these in your travel demand models for the next LRTP study?

	Yes	No	Maybe later
Car Sharing Systems (like Zipcar)			
Ride Sharing Systems (like Uber)			
Electric vehicles and locations of charging stations			
Real time traveler information			

Feel free to provide additional comments. We will contact you for further inputs and will share with you the findings form our study. E-mail your response to siva@ce.ufl.edu.

Thank you,
Siva Srinivasan (Principal Investigator) and Ed Hutchinson (Project Manager)

Table A1.1 Respondent List

MPO	Received Survey
Bay County (WFRPC)	Y
Broward	Y
Captial Region	Y
Charlotte County / Punta Gorda MPO	Y
Collier MPO	N
Florida Alabama (WFRPC)	Y
Gainesville	Y
Heartland	Y
Hernando-Citrus	Y
Hillsborough	Y
Indian River	Y
Lake-Sumter	N
Lee	Y
Martin	Y
Metroplan Orlando	Y
Miami Dade	Y
NorthFlorida	Y
Ocala /Marion County	Y
Okaloosa-Walton (WFRPC)	Y
Palm Beach	Y
Pasco	N
Pinellas	Y
Polk	Y
RivertoSea	Y
Sarasota/Manatee	Y
Space Coast	N
St Lucie	Y

APPENDIX 2: AV IMPACTS ON PLANNING GOALS

The Florida Transportation Plan[1] identifies seven major goals and several objectives within each of these goals. This appendix summarizes these goal and visions and examines the promises and challenges offered by the AV/CV technology in the context of these goals and objectives. This discussion is aimed at providing a baseline against which the MPOs can evaluate the impacts of AV on their own goals.

Goal 1 Safety and Security for Residents, Visitors, and Businesses
Objectives for Goal 1

- Prevent transportation-related fatalities and injuries
- Reduce the number of crashes on the transportation system
- Prevent and mitigate transportation-related security risks
- Provide transportation infrastructure and services to help prepare for, respond to, and recover from emergencies

Table A2.1 AV Impacts on Goal 1

Promises of AV/CV technology	Challenges of AV/CV Technology
• The AV technology promises significant improvements to transportation safety by reducing/eliminating driver errors and by reducing reaction times to negligible amounts • Connected systems can provide for faster access of emergency vehicles to incident scenes • Homogenizes traffic flow (speeds/acceleration/deceleration etc) reducing the risk of crashes	• Mixed mode traffic operations (some autonomous and some person-driven) can increase safety and security risks • Cybersecurity becomes a great concern • Lack of inter-operability of competing technologies can increase safety risks • Vehicle-pedestrian interactions have to be resolved

Goal 2 Agile, Resilient, and Quality Infrastructure
Objectives for Goal 2

- Meet or exceed industry, state, national, or international standards for infrastructure quality, condition, and modes of transportation performance for all
- Optimize the functionality and efficiency of existing infrastructure and right-of-way
- Adapt transportation infrastructure and technologies to meet changing customer needs
- Increase the resiliency of infrastructure to risks, including extreme weather and other environmental conditions

[1] http://floridatransportationplan.com/

Table A2.2 AV Impacts on Goal 2

Promises of AV/CV technology	Challenges of AV/CV Technology
• Increases speed and homogenizes traffic flow (speeds/acceleration/deceleration etc) to increase the efficiency of transportation system	• Requires significant infrastructure upgrades to support the AV/CV technology • Performance of AV/CV under extreme weather conditions are unknown

Goal 3 Efficient and Reliable Mobility for People and Freight
Objectives for Goal 3

- Reduce delays related to bottlenecks, gaps, and crashes and other incidents for all modes of Florida's transportation system
- Increase the reliability of all modes of Florida's transportation system
- Increase customer satisfaction with Florida's transportation system and regulatory processes for residents, visitors, and businesses
- Increase the efficiency of the supply chain for freight moving to, from, and through Florida
- Increase the efficiency and flexibility of transportation related regulatory processes

Table A2.3 AV Impacts on Goal 3

Promises of AV/CV technology	Challenges of AV/CV Technology
• Can reduce delays due to bottlenecks by dynamic re-routing of traffic • Can reduce incidents and incident clearance times thereby reducing delays due to incidents • Improve reliability by providing passengers with real-time travel information • Decrease the monetary value of travel time (increase travel comfort)	• Benefits may not be realized under mixed-mode traffic operations • Performance of AV/CV under extreme weather conditions are unknown • Cybersecurity becomes a great concern

Goal 4 More Transportation Choices for People and Freight
Objectives for Goal 4

- Increase the use of new mobility options and technologies such as shared, automated, and connected vehicles
- Increase the share of person trips using public transportation and other alternatives to single occupancy motor vehicles
- Increase the number of quality options for visitor travel to, from, and within Florida
- Increase the number of quality options for moving freight to, from, and within Florida
- Increase the efficiency and convenience of connecting between multiple modes of transportation

Table A2.4 AV Impacts on Goal 4

Promises of AV/CV technology	Challenges of AV/CV Technology
• AV/CV technology is extremely compatible with the concept of shared mobility • Provides transportation choices for the mobility-disadvantaged like the elderly and disabled • Provide quality transportation to visitors who may be unfamiliar with their destination • Shared mobility can reduce the number of vehicles required to meet travel demand • AV/CV can be an excellent last-mile solution for freight and mass transit • AV/CV can be used to facilitate multi-modal trips	• Public perception towards adoption and use of AV/CV • Per-mile cost of travel could be a critical factor • AV/CV may decrease the share of walking and biking • Decreased value of travel time could lead to increased trip lengths and more single-occupant vehicle trips

Goal 5 Transportation Solutions that Support Florida's Global Economic Competitiveness
Objectives for Goal 5

- Provide transportation infrastructure and services to support job growth in transportation-dependent industries and clusters
- Increase transportation connectivity between Florida's economic centers and regions
- Increase transportation connectivity between Florida and global and national trading partners and visitor origin markets
- Increase the number of skilled workers in Florida's transportation-related industries

Table A2.5 AV Impacts on Goal 5

Promises of AV/CV technology	Challenges of AV/CV Technology
• Improve freight transportation by truck platooning • Automated movement of freight between inter-modal facilities (say a sea port and an airport) • Attract skilled workforce with a transportation system of their choice	• Decreased jobs in certain sectors because of automation

Goal 6 Transportation Solutions that Support Quality Places to Live, Learn, Work, and Play
Objectives for Goal 6

- Plan and develop transportation systems that reflect regional and community values, visions, and needs
- Increase customer satisfaction with Florida's transportation system

- Provide convenient, efficient accessibility to the transportation system for Florida's residents and visitors
- Provide transportation solutions that contribute to improved public health

Table A2.6 AV Impacts on Goal 6

Promises of AV/CV technology	Challenges of AV/CV Technology
• Provides transportation choices for the mobility-disadvantaged like the elderly and disabled • Provide quality transportation to visitors who may be unfamiliar with their destination • Reduce emissions and improve air quality • Reduce traffic crashes and fatalities	• AV/CV may decrease the share of walking and biking

Goal 7 Transportation Solutions that Support Florida's Environment and Conserve Energy
Objectives for Goal 7

- Plan and develop transportation systems and facilities in a manner that protects, and where feasible, restores the function and character of the natural environment and avoids or minimizes adverse environmental impacts
- Decrease transportation-related air quality pollutants and greenhouse gas emissions
- Increase the energy efficiency of transportation
- Increase the diversity of transportation-related energy sources, with emphasis on cleaner and more efficient fuels

Table A2.7 AV Impacts on Goal 7

Promises of AV/CV technology	Challenges of AV/CV Technology
• Minimize the needs for expansion of road surface capacity • Minimize the need for parking spaces • AV could be electric vehicles • Reduce emissions via smooth traffic flow • Shared mobility models may be better suited for electric and other green energy sources (fewer charging stations)	• Increased trip lengths may increase overall energy consumption of the transportation sector • Mobility provided to new segments of population can increase energy demand • Zero-occupant trips may increase energy demand

APPENDIX 3: TERMINOLOGY

This appendix addresses the lack of a consistent and universal vocabulary to describe the emergent autonomous-, automated- and connected- technologies and associated vehicle types. Definitions of terms from a variety of sources are presented while also demonstrating that the same terms have been used rather interchangeably in many ways. The intent of this exercise is to alert readers of literature in this field to be cognizant of this issue and to actively seek for specific definitions of terms in any document they may read.

First, we start by noting that there are fairly-well established definitions of *levels of automation* from at least three major highway/vehicle agencies (Table A3.1). NHTSA[1] and BASt[2] present five levels while SAE[3] identifies six. A schematic figure comparing these definitions is presented in Figure A3.1[4]. Table A3.2 presents some of the terms used by auto manufacturers to represent their vehicles with different levels of automation.

Yet, in the literature, "automated vehicles" is implicitly treated as a specific type and the term is often used interchangeably with terms such as "autonomous vehicles", "self-driving vehicles", and "driverless cars" thereby disregarding the fundamental idea that there are various levels of automation of which "full autonomy" is one. Even the abbreviation "AV" is sometimes used to refer to (the full range of) "automated vehicles" while in other places it refers to "autonomous vehicles" (often implying the top two levels of automation per NHTSA classification).

Further, this issue of inconsistent vocabulary is also evident in the legislative language. Table A3.3[5] presents a comparative summary of the term "motor vehicles" as defined in the seven locations (six states and Washington D.C.) that have legislation on automated/autonomous vehicles. This is of interest as Automated/autonomous vehicles are generally defined as "motor vehicles" with certain additional characteristics. In general, fixed-guideway transit such as light /heavy rail and people mover systems are explicitly excluded from the definition of a motor vehicle. However, other types of vehicles such as motorcycles, buses, trucks and RVs are not. Thus, it is useful to note that "automated/autonomous vehicles" could include more types of vehicles than just the passenger car.

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[1] http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development

[2] http://onlinepubs.trb.org/onlinepubs/conferences/2012/Automation/presentations/Gasser.pdf

[3] http://www.sae.org/misc/pdfs/automated_driving.pdf

[4] https://cyberlaw.stanford.edu/files/blogimages/LevelsofDrivingAutomation.pdf

[5] http://leg.state.nv.us/NRS/NRS-484A.html#NRS484ASec130
http://www.dmv.ca.gov/portal/dmv/detail/pubs/vctop/vc/d1/670
http://legislature.mi.gov/doc.aspx?mcl-257-33
http://www.dcregs.dc.gov/Gateway/FinalAdoptionHome.aspx?RuleVersionID=4371516
http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&Search_String=&URL=0300-0399/0320/Sections/0320.01.html
http://law.justia.com/codes/new-jersey/2013/title-39/section-39-1-1/
https://www.tn.gov/lawsandpolicies/article/55-1-103.-autocycle-motor-bicycle-motor-vehicle-motorcycle-vehicle-and-frei#sthash.TIYoW83q.dpuf
http://www.legis.nd.gov/cencode/t39c01.pdf?20160221094221

Table A3.1 Levels of Automation

NHTSA	SAE	BASt
No-Automation (Level 0): The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times.	**0: No Automation :** the full-time performance by the *human driver* of all aspects of the *dynamic driving task* , even when enhanced by warning or intervention systems	**Driver Only:** Human driver executes manual driving task
Function-specific Automation (Level 1): Automation at this level involves one or more specific control functions. Examples include electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone.	**1: Driver Assistance:** the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving* task.	**Driver Assistance:** The driver permanently controls either longitudinal or lateral control. The other task can be automated to a certain extent by the assistance system.
Combined Function Automation (Level 2): This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centering.	**2: Partial Automation:** the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*.	**Partial automation:** The system takes over lateral control, the driver shall permanently monitor thelongitudinal and system and shall be prepared to take over control at any time
Limited Self-Driving Automation (Level 3): Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The Google car is an example of limited self-driving automation.	**3: Conditional Automation:** the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene.*	**High automation:** The system takes over longitudinal and lateral control; the driver is no longer required to permanently monitor the system. In case of a take-over request, the driver must take-over control with a certain time buffer.
Full Self-Driving Automation (Level 4): The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.	**4: High Automation:** the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* , even if a *human driver* does not respond appropriately to a *request to intervene.*	**Full automation:** The system takes over longitudinal and lateral control completely and permanently. In case of a takeover request that is not followed, the system will return to the minimal risk condition by itself.
	5: Full automation: the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*.	

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

The table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BASt) and approximately correspond to those described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
Human driver monitors the driving environment								
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
Automated driving system ("system") monitors the driving environment								
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	-	

Figure A3.1 Comparison of the levels of Automation

Table A3.2 Selected terms used by auto manufacturers to represent automation

Company	Terminology L2/L3-4	References
GM	L2: Super Cruise L3: "hands-free and feet-free", Super Cruise, colloquial use of autonomous, self-driving	http://www.cnet.com/news/gm-plans-to-launch-hands-free-driving-by-2016/#ftag=CAD3440c1f http://blogs.scientificamerican.com/plugged-in/2014/09/09/safety-is-primary-focus-in-gms-driverless-vehicle-announcement/ http://www.autonews.com/article/20130909/OEM06/309099956/gms-step-by-step-approach-toward-self-driving-cars
Audi	L2: driver assistance system (e.g. traffic jam assist, etc.) L3: colloquial use of driverless	http://www.cnet.com/news/audi-ready-to-test-autonomous-cars-on-public-roads/ https://www.audi-mediaservices.com/publish/ms/content/en/public/pressemitteilungen/2015/01/06/ces.html https://www.audi-mediaservices.com/publish/ms/content/en/public/hintergrundberichte/2012/03/08/networked_mobility/driver_assistance0.html
Mercedes Benz	L2: Steering Assist L3: colloquial use of driverless	http://www.cnet.com/products/2014-mercedes-benz-s550/
Ford	L2: driver-assist technologies." L3: colloquial use of driverless, self-driving, autonomous	http://www.bloomberg.com/news/2015-01-06/ford-ceo-fields-predicts-driverless-cars-on-roads-in-five-years.html https://media.ford.com/content/dam/fordmedia/North%20America/US/2015/01/06/MarkFieldsCESRemarks.pdf
Toyota	Automated Highway Driving Assist (AHDA)	http://www.cnet.com/news/toyota-rolling-out-near-autonomous-cars-in-five-years/
BMW	L2: BMW ConnectedDrive Driver Assistance	http://www.bmw.com/com/en/owners/connected_drive_services/how_to_use/index.html#driver_assistance
Volkswagen	L2: Temporary Auto Pilot L3: Temporary Auto Pilot	http://www.volkswagenag.com/content/vwcorp/content/en/innovation/driver_assistance/Temporary_Auto_Pilot.html
Tesla	L2: autopilot L3: autopilot, autonomous	http://www.cnet.com/news/elon-musk-tweets-invite-to-work-on-teslas-self-driving-model-s/

Table A3.4[1] presents a comparative summary of the terms "automated/autonomous vehicles" across the seven locations. Five of the seven legislations use the term "autonomous vehicle" and "autonomous technology". Broadly these refer to the vehicle's capabilities to navigate itself (for the entire trip) without the active involvement of a human driver and often excludes technology that can only perform such a task under specialized environments (for example, a vehicle with only adaptive cruise control and lane-maintenance may not be considered an autonomous vehicle even though the vehicle could "drive itself" along stretches of freeways. In contrast, Michigan and North Dakota use the term "Automated motor vehicle" instead of autonomous vehicles even though these do refer vehicles with full automation. The North Dakota legislation makes explicit reference to the Society of Automotive Engineers' definitions about levels of automation; none of the other cases make such explicit reference to either SAE or NHTSA definitions. Finally, it is also interesting to note that New Jersey also defines "artificial intelligence" as a key component of "autonomous technology".

The visioning study undertaken by PennDOT[2] defines "autonomous vehicles" to be consistent with NHTSA levels 3 and 4 of automation, which is also consistent with the use the same term in the legislations of several states. However, legislation from Michigan and North Dakota use the term "automated vehicle" to refer to vehicles that can essentially function without a human operator. Further, North Dakota is the only case in which legislation makes an explicit reference to the SAE levels of automation in its language.

In sum, autonomous vehicles should be considered as a subset of automated vehicles since the former involve the highest level(s) of automation even though the current literature is not consistent in its terminology.

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[1] http://www.leg.state.nv.us/NRS/NRS-482A.html
http://www.dmv.ca.gov/portal/dmv/detail/pubs/vctop/vc/d1/670
http://www.legislature.mi.gov/documents/2013-2014/publicact/htm/2013-PA-0231.htm
http://dcclims1.dccouncil.us/images/00001/20130110191554.pdf
http://www.myfloridahouse.gov/Sections/Documents/loaddoc.aspx?FileName=_h1207er.docx&DocumentType=Bill&BillNumber=1207&Session=2012
http://www.njleg.state.nj.us/2014/Bills/S1000/734_I1.HTM
http://www.capitol.tn.gov/Bills/109/Bill/SB0598.pdf
http://www.legis.nd.gov/assembly/64-2015/documents/15-0167-03000.pdf?20160221093318

[2] http://trid.trb.org/view.aspx?id=1324787

Table A3.3 Definitions of "Motor Vehicle"

Nevada	"Motor vehicle" means every vehicle which is self-propelled but not operated upon rails.
California	A "vehicle" is a device by which any person or property may be propelled, moved, or drawn upon a highway, excepting a device moved exclusively by human power or used exclusively upon stationary rails or tracks.
Michigan	"Motor vehicle" means every vehicle that is self-propelled, but for purposes of chapter 4 of this act motor vehicle does not include industrial equipment such as a forklift, a front-end loader, or other construction equipment that is not subject to registration under this act. Motor vehicle does not include an electric patrol vehicle being operated in compliance with the electric patrol vehicle act. Motor vehicle does not include an electric personal assistive mobility device. Motor vehicle does not include an electric carriage.
DC	Motor Vehicle - any vehicle propelled by internal-combustion engine, electricity, or steam, including any non-operational vehicle that is being restored or repaired. The term "motor vehicle" shall not include road rollers, farm tractors, vehicles propelled only upon stationary rails or tracks, electric personal assistive mobility devices, and battery-operated wheelchairs when operated by a handicapped person at speeds not exceeding 10 miles per hour.
Florida	20.01 Definitions, general.—As used in the Florida Statutes, except as otherwise provided, the term: (1) "Motor vehicle" means (a) An automobile, motorcycle, truck, trailer, semitrailer, truck tractor and semitrailer combination, or any other vehicle operated on the roads of this state, used to transport persons or property, and propelled by power other than muscular power, but the term does not include traction engines, road rollers, special mobile equipment as defined in s. 316.003(48), vehicles that run only upon a track, bicycles, swamp buggies, or mopeds. (b) A recreational vehicle-type unit primarily designed as temporary living quarters for recreational, camping, or travel use, which either has its own motive power or is mounted on or drawn by another vehicle
New Jersey	"Motor vehicle" includes all vehicles propelled otherwise than by muscular power, excepting such vehicles as run only upon rails or tracks and motorized bicycles.
Tenessee	(c) "Motor vehicle" means every vehicle that is self-propelled, excluding motorized bicycles and every vehicle that is propelled by electric power obtained from overhead trolley wires. "Motor vehicle" means any low speed vehicle, or medium speed vehicle as defined in this chapter. "Motor vehicle" means any mobile home or house trailer as defined in § 55-1-105.
North Dakota	Motor vehicle includes every vehicle that is self-propelled, every vehicle that is propelled by electric power obtained from overhead trolley wires, but not operated upon rails, and, for purposes of motor vehicle registration, title registration, and operator's licenses, motorized bicycles. The term does not include a snowmobile as defined in section 39-24-01.

Table A3.4 Definitions of "Automated / Autonomous Vehicles"

Nevada	Autonomous vehicle is a motor vehicle that is equipped with autonomous technology. "Autonomous technology" means technology which is installed on a motor vehicle and which has the capability to drive the motor vehicle without the active control or monitoring of a human operator. The term does not include an active safety system or a system for driver assistance, including, without limitation, a system to provide electronic blind spot detection, crash avoidance, emergency braking, parking assistance, adaptive cruise control, lane keeping assistance, lane departure warning, or traffic jam and queuing assistance, unless any such system, alone or in combination with any other system, enables the vehicle on which the system is installed to be driven without the active control or monitoring of a human operator.
California	"Autonomous vehicle" means any vehicle equipped with autonomous technology that has been integrated into that vehicle. Autonomous technology" means technology that has the capability to drive a vehicle without the active physical control or monitoring by a human operator (similar to Nevada definition)
Michigan	"Automated motor vehicle" means a motor vehicle on which automated technology has been installed, either by a manufacturer of automated technology or an upfitter that enables the motor vehicle to be operated without any control or monitoring by a human operator. Automated motor vehicle does not include a motor vehicle enabled with 1 or more active safety systems or operator assistance systems, including, but not limited to, a system to provide electronic blind spot assistance, crash avoidance, emergency braking, parking assistance, adaptive cruise control, lane‑keeping assistance, lane departure warning, or traffic jam and queuing assistance, unless 1 or more of these technologies alone or in combination with other systems enable the vehicle on which the technology is installed to operate without any control or monitoring by an operator. "Automated technology" means technology installed on a motor vehicle that has the capability to assist, make decisions for, or replace an operator. "Automatic mode" means the mode of operating an automated motor vehicle when automated technology is engaged to enable the motor vehicle to operate without any control or monitoring by an operator.
DC	"Autonomous vehicle" means a vehicle capable of navigating District roadways and interpreting traffic-control devices without a driver actively operating any of the vehicle's control systems. The term "autonomous vehicle" excludes a motor vehicle enabled with active safety systems or driver- assistance systems, including systems to provide electronic blind-spot assistance, crash avoidance, emergency braking, parking assistance, adaptive cruise control, lane-keep assistance, lane departure warning, or traffic-jam and queuing assistance, unless the system alone or in combination with other systems enables the vehicle on which the technology is installed to drive without active control or monitoring by a human operator.

Table A3.4 (Continued) Definitions of "Automated / Autonomous Vehicles"

Florida	Autonomous vehicle is any vehicle equipped with autonomous technology. the term "autonomous technology" means technology installed on a motor vehicle that has the capability to drive the vehicle on which the technology is installed without the active control or monitoring by a human operator. The term excludes a motor vehicle enabled with active safety systems or driver assistance systems, including, without limitation, a system to provide electronic blind spot assistance, crash avoidance, emergency braking, parking assistance, adaptive cruise control, lane keep assistance, lane departure warning, or traffic jam and queuing assistant, unless any such system alone or in combination with other systems enables the vehicle on which the technology is installed to drive without the active control or monitoring by a human operator
New Jersey	"Autonomous vehicle" means a motor vehicle that uses artificial intelligence, sensors, global positioning system coordinates, or any other technology to carry out the mechanical operations of driving without the active control and continuous monitoring of a human operator. "Artificial intelligence" means the use of computers and related equipment to enable a machine to duplicate or mimic the behavior of human beings. "Autonomous mode" means the operation of the autonomous vehicle without the active control of a human being.
Tennessee	"autonomous technology" means technology installed on a motor vehicle that has the capability to drive the motor vehicle without the active physical control or monitoring by a human operator.
North Dakota	Automated motor vehicle means a vehicle capable of operating in a full automation mode where full automation is defined by the Society of Automotive Engineers standard, J3016, section 5.6 issued January 2014, as the unconditional, full-time performance by an automated driving system of all aspects of the dynamic driving task.

The reader will also note that, as defined, the autonomy of the vehicle is from the perspective of the driver and not from the transportation system. It could be argued that, the more the vehicles can "talk" to the transportation system, the more independent the vehicle can be from the driver. Therefore, it is important to discuss automation in along with connectivity. Connectivity, in general, includes vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and the broader vehicle-to-everything (V2X) technologies. However, it is useful to note that NHTSA and other definitions discussed previously are focused entirely on automation and not on connectivity. Broadly speaking, at any level of automation, there is no distinction according to the levels or types of connectivity. While connectivity may be a desirable/necessary feature to achieve higher levels of automation, at lower levels of automation, connectivity may not be required from the technical stand point. At the same time, a connected vehicle that provides only warning and is incapable of taking over the controls is also classified as a vehicle with no automation. Therefore, connected–vehicle systems that provide driver-assistance but cannot replace a driver over extended periods are effectively treated as no-different from conventional vehicles (lowest level of automation) in the current AV classification schemes. Overall, there is value to developing a vocabulary of terms that is inclusive of both levels of automation and connectivity as a means to comprehensively describe and analyze emergent transportation (vehicle and infrastructure) systems.

Finally, it is also useful to point out that the majority of discussions on "automated and connected vehicles" are implicitly about the "passenger car" as we know it today. There is also increasing interest in automation of freight transportation by trucks. However, these technologies also hold promise for other conventional ground-transportation modes such as public transportation, trucks, and service vehicles (such as ambulance and fire trucks). While a state transportation agency is interested in all modes of transportation, the private sector stakeholders for the different modes are not the same. Therefore, care must be administered in synthesizing knowledge on automated/autonomous vehicles since material from each source is generally likely to be focused on one specific mode. Finally, it is also important to understand that, fixed-guideway systems like rail are generally excluded from discussions of automated/autonomous vehicles but these are still relevant in the context of connected vehicles.

In the context of AV/CV as applied to freight, platooning is an important concept as it has the potential to improve safety, increase roadway capacity (by reduced headways) and decrease fuel consumption. The recent Florida legislation provides a legal definition of "driver-assistive truck platooning technology"[1].

> *Vehicle automation and safety technology that integrates sensor array, wireless vehicle-to-vehicle communications, active safety systems, and specialized software to link safety systems and synchronize acceleration and braking between two vehicles while leaving each vehicle's steering control and systems command in the control of the vehicle's driver in compliance with the National Highway Traffic Safety Administration rules regarding vehicle-to-vehicle communications.*

[1] §239, Fl. Stat. (2016). http://laws.flrules.org/2016/239 (CHAPTER 2016-239 pp. 10)

APPENDIX 4: AV SCENARIOS AND PATHWAYS TO FUTURE

Several uncertain factors could dictate a future with fully autonomous vehicles as the norm. The fundamental technologies required for full automation are still under development and testing and, therefore, the true capabilities of these and the associated costs are unknown. Other factors such as user perceptions, nature of regulations, the economy, the environment, the advent of new business models, changes in traveler attitudes towards vehicle ownership can all have impacts on how the future shapes up.

Scenario planning is a systematic procedure that can be used to address the uncertainties introduced by disruptive technologies such as AV on the transportation planning process. Broadly, this procedure begins with the identification of key factors and driving forces. Next, the impact and uncertainty associated with the driving forces discussed leading to the construction of scenario matrices. The consequences of each scenario may then be discussed. The overall procedure has been discussed in several documents.[1,2]

In an AV scenario-planning exercise conducted in the Netherlands[3], five driving factors were identified: Technology, Policy, Customer Attitudes, Economy and Environment. Of these technology and policy were rated to have the most impact and also most uncertainty associated with them. On the contrary, environment was stated to have least impact and least uncertainty among the driving forces. The study conducted in Texas[4] identified Society, Technology, Policy, and Economy as the "influencing areas" (or driving factors).

The Dutch study identified four potential AV futures based on combinations of rate of technology development and the regulatory environment in the form of policies (Figure A4.1, reproduced from the study).

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[1] http://www.dvrpc.org/reports/WP14038.pdf

[2] https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/scenario_planning_guidebook/fhwahep16068.pdf

[3] Milakis, D., Snelder, M., Arem, B. Van, Wee, B. Van, Homem, G., & Correia, D. A. (2015). *Development of automated vehicles in the Netherlands: scenarios for 2030 and 2050*. Delft, The Netherlands

[4] http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/161504-1.pdf

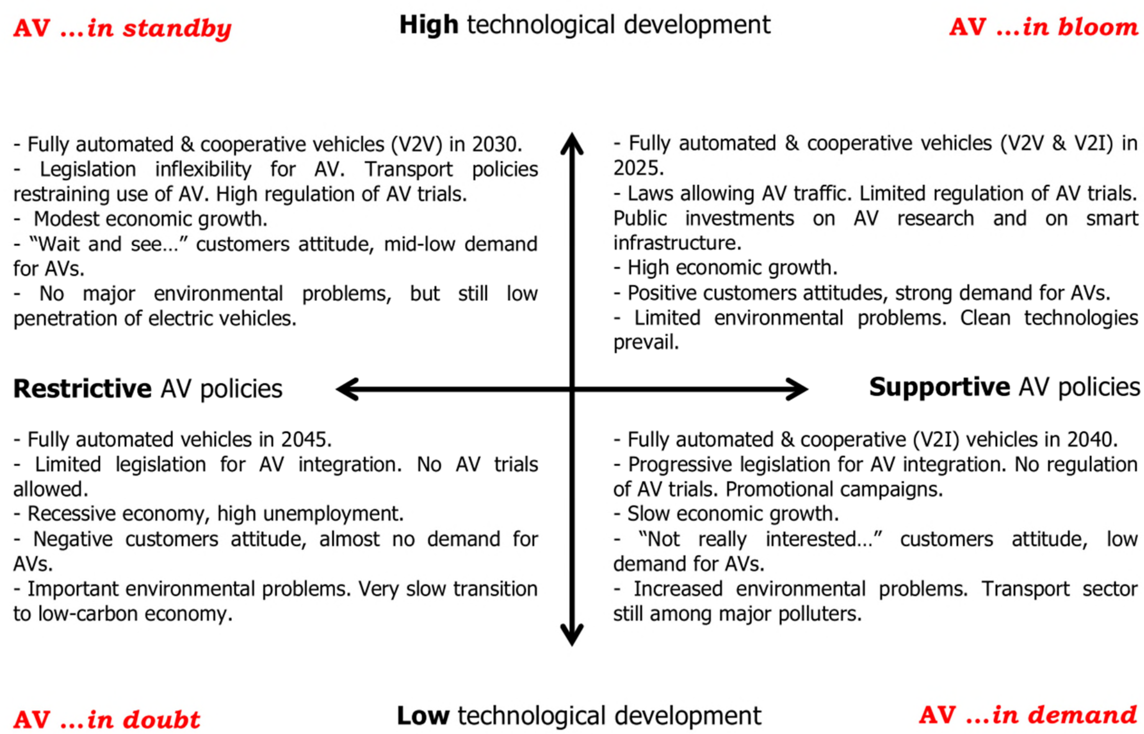

Figure A4.1. AV Scenarios from the Dutch Study

A study by Roland Berger[1] also presents alternate futures but based on the perspective of manufacturing and the ownership of vehicles and technology (Figure A4.2 reproduced from the study).

[1] RolandBerger. (2014). *Think Act: Autonomous Vehicles.*

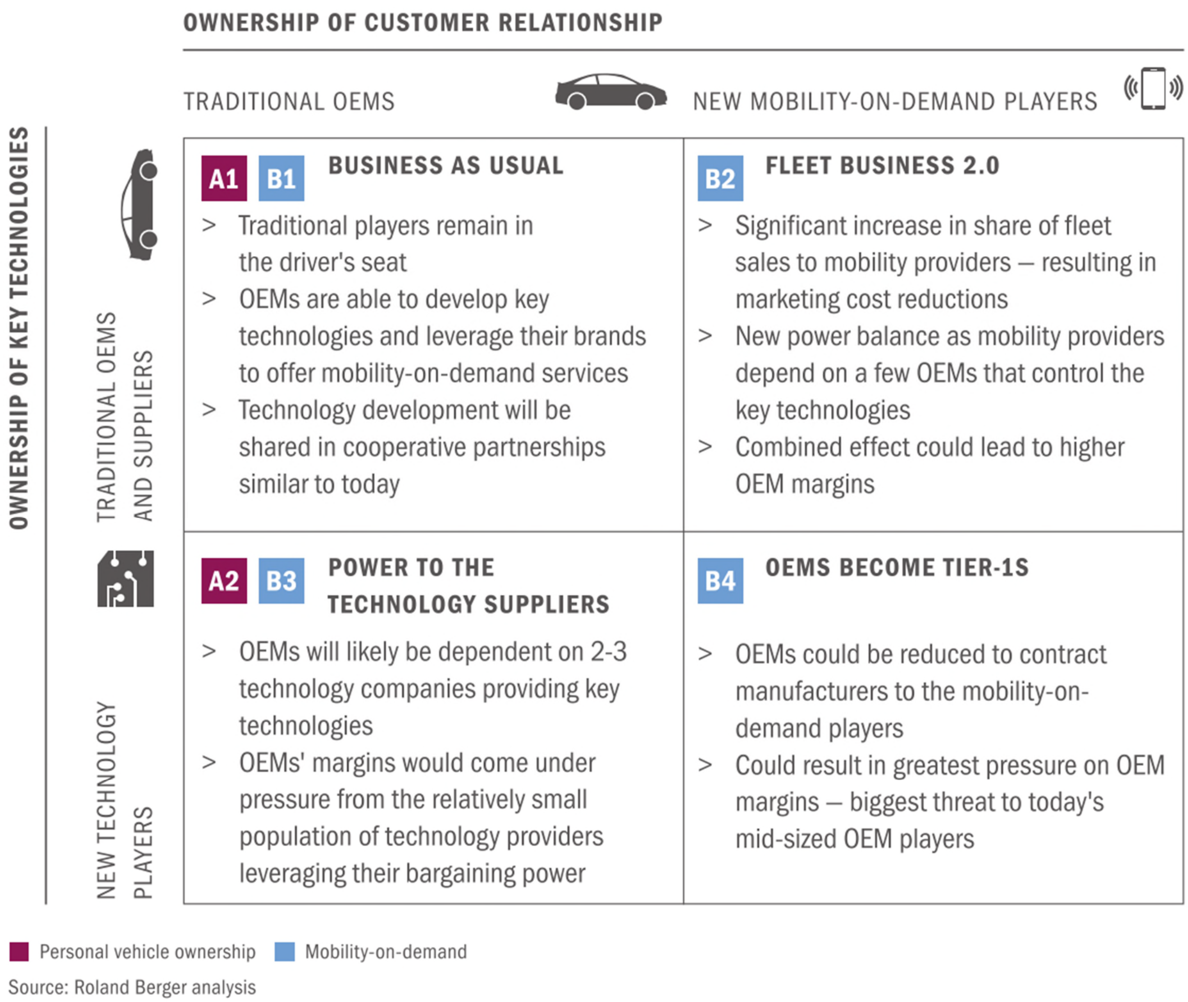

Figure A4.2 AV Futures Based on Manufacturing and Ownership

Next we examine the projected timelines for availability and adoption of AVs. Based on a survey of AV OEMs[1] on when they believe AVs will be commercially available, Full-self driving cars (NHTSA Level 4) are estimated to available 7-12+ years into the future while limited self-driving (NHTSA Level 3) will be available 3-10+ years in the future. Figure 3.3[2] (reproduced from original document) presents projections of sales of fully autonomous vehicles, their share in the fleet and the proportion of travel that will be undertaken by these vehicles. These projections assume that AVs will be available with a large price premium from 2020 and with time there is a decrease in costs as well as an increase in the number of vehicles manufactured with these technology as standard features.

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[1] Wagner, Jason; Baker, Trey; Goodin, Ginger; Maddox, J. (2014). Automated Vehicles: Policy Implications Scoping Study. http://d2dtl5nnlpfr0r.cloudfront.net/swutc.tamu.edu/publications/technicalreports/600451-00029-1.pdf

[2] http://www.vtpi.org/avip.pdf

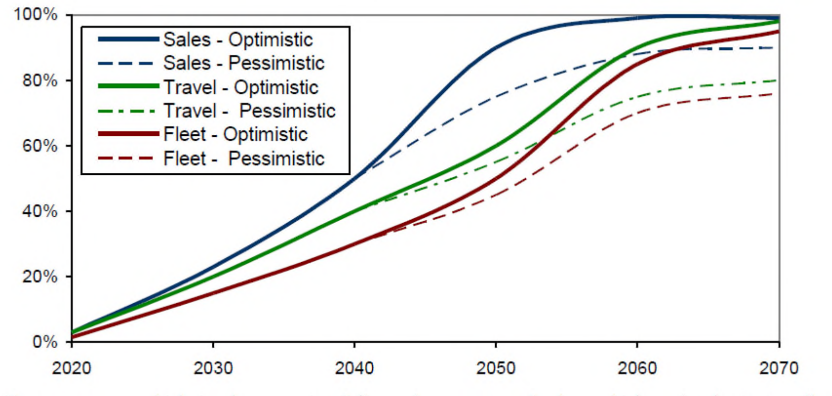


Figure A4.3 Projections of AVs

However, there is significant uncertainty in these projections. In a white paper prepared in 2013[1], the following (variations in) projections are reported:

- 20-30 million to 95 million autonomous cars around 2030 to 2035.
- 75% of all the vehicles will be autonomous by 2040.
- autonomous cars that are highly automated (but not fully self-driving) to have a market share of around 15 to 20 percent globally by 2030.
- autonomous vehicles will gradually gain traction in the market over the coming two decades and by 2035, sales of autonomous vehicles will reach 95.4 million annually, representing 75% of all light-duty vehicle sales."
- major share of vehicles (and travel) may be autonomous only in 2040s through 2060s, yet with a mix of human driven vehicles.

More recently, projections of 10 million[2] self-driving cars by 2020 and 76 million[3] autonomous vehicles by 2035 have also been made.

As AVs are introduced into the market, it is unlikely that they can be used everywhere right away. Figure A4.4[4](reproduced from the original) presents an example of how AVs may get deployed across the different facility types over time.

[1] http://www.automatedvehicleinstitute.org/pdf/TAVI_8-CapacityPinjari.pdf
[2] http://www.businessinsider.com/report-10-million-self-driving-cars-will-be-on-the-road-by-2020-2016
[3] http://www.eetimes.com/document.asp?doc_id=1329860
[4] Shladover, S. (2015). Automation Deployment Paths: Limiting Automation Functionality or Geographic Scope

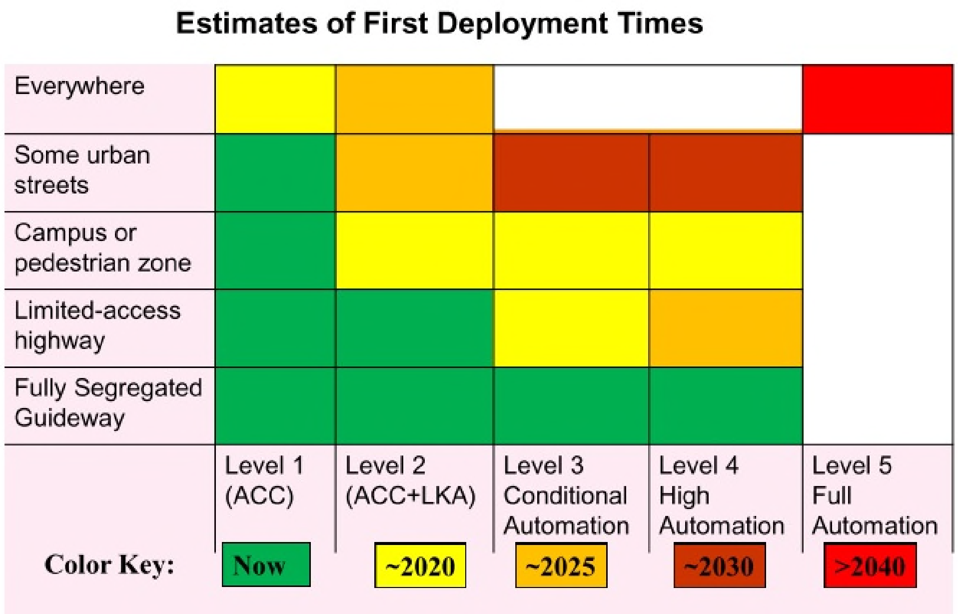


Figure A4.4 Locations of Deployment by Level of Automation (Source Shadover 2015)

A Fehr and Peers report[1] (Figure A4.5 reproduced from the document) presents another example of how AVs may get deployed across the different facility types over time.

Exclusive freeway lanes	2025-2030
Mixed freeway lanes and ramps	2030-2035
Auto-dominated arterials	2035-2040
Multi-modal streets and intersections	2040-2050
Vehicles operating without a legal driver aboard on:	
private streets and self-parking in private lots	2040-2050
public streets and lots	2050+

Figure A4.5 Locations of Deployment by Level of Automation

Taking a slightly different approach studies by Roland Berger[2] and International Transport Forum[3] envisions that earlier deployments of automated vehicle technologies will focus on safety, parking, and lane maintenance that in turn will lead into vehicles with more autonomy

[1] Bierstedt, J., Gooze, A., Gray, C., Peterman, J., Raykin, L., & Walters, J. (2014). Effects of next-generation vehicles on travel demand and highway capacity, (JANUARY), 1–27. http://orfe.princeton.edu/~alaink/Papers/FP_NextGenVehicleWhitePaper012414.pdf

[2] RolandBerger. (2014). *Think Act: Autonomous Vehicles*.

[3] http://www.internationaltransportforum.org/pub/pdf/15CPB_AutonomousDriving.pdf

under more situations.

All these studies generally indicate AVs entering the traffic stream in limited access facilities in possibly exclusive lanes and then slowly proliferating into other parts of the network.

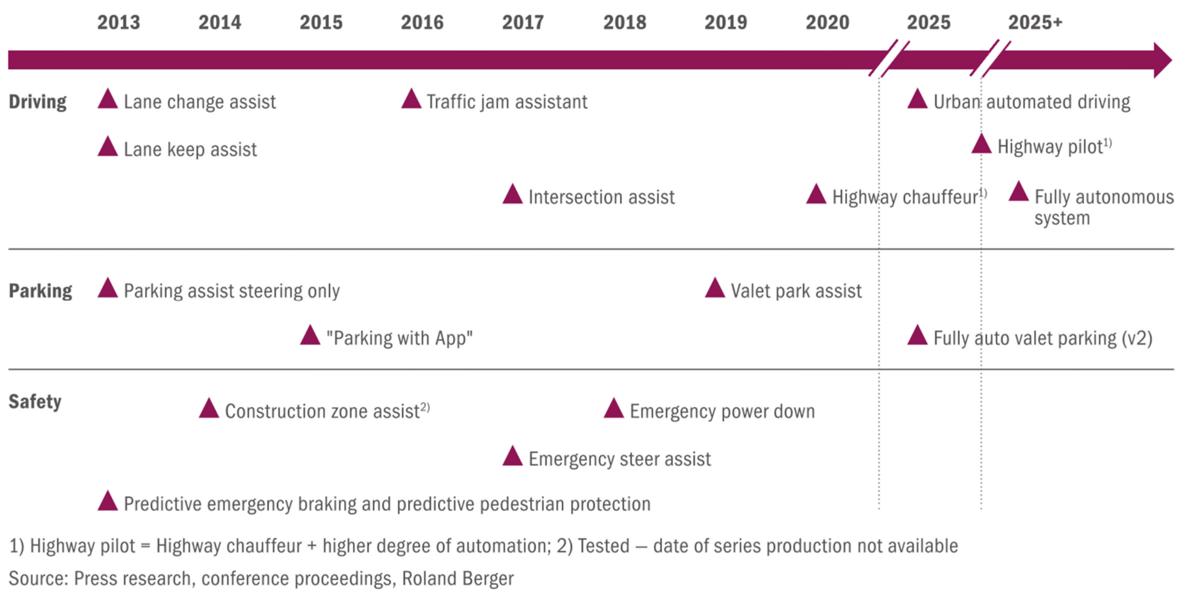


Figure A4.6 Deployment by Level of Automation (Source Roland Berger Analysis)

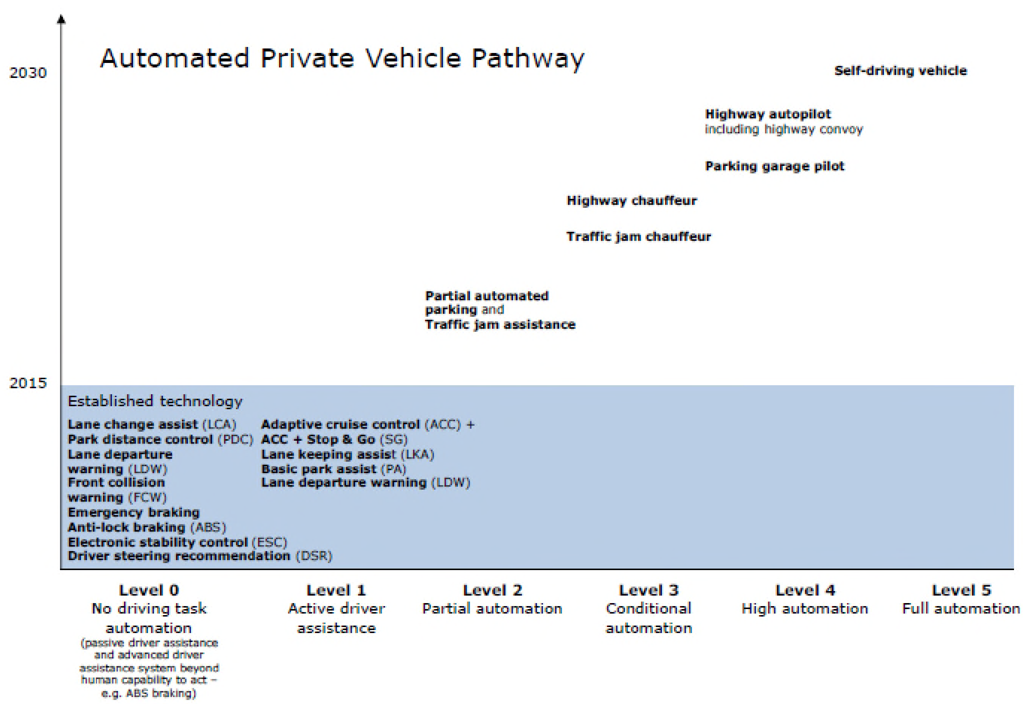
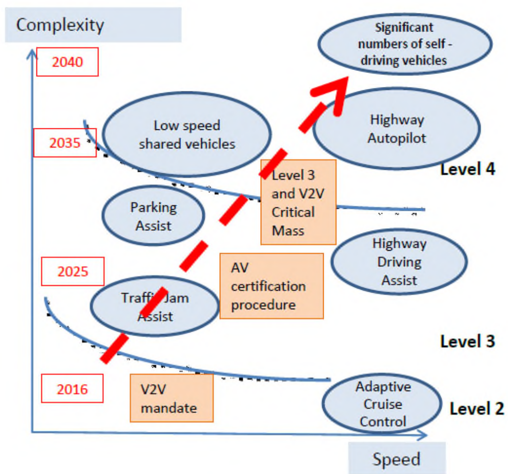


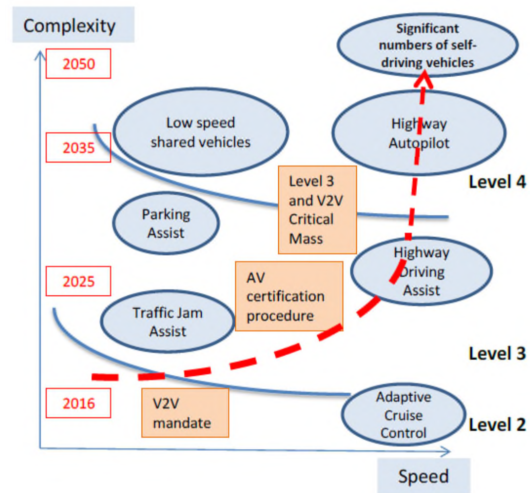
Figure A4.7 Deployment by Level of Automation (Private Vehicles)

A study undertaken in Texas[1] (Figure A4.8 reproduced from the original) presents two possible approaches/paths for the technology to evolve though automation under select conditions to full automation for a large number of vehicles. These are presented in the next figure as “Revolutionary” and “Evolutionary” approaches.



Source: Adapted from European Technology Platform on Smart Systems Integration 2015.

Figure 5. Revolutionary Path of Deployment.



Source: Adapted from European Technology Platform on Smart Systems Integration

Figure 6. Evolutionary Path of Deployment.

Figure A4.8 Alternate Pathways to Deployment

All discussion thus far has focused on the private vehicle. The International Transport Forum[2] has also developed pathways for “urban mobility” (shared mobility systems) and for trucks for freight movements. These are presented in Figures A4.9 and A4.10 (reproduced from original).

[1] http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/161504-1.pdf
[2] http://www.internationaltransportforum.org/pub/pdf/15CPB_AutonomousDriving.pdf

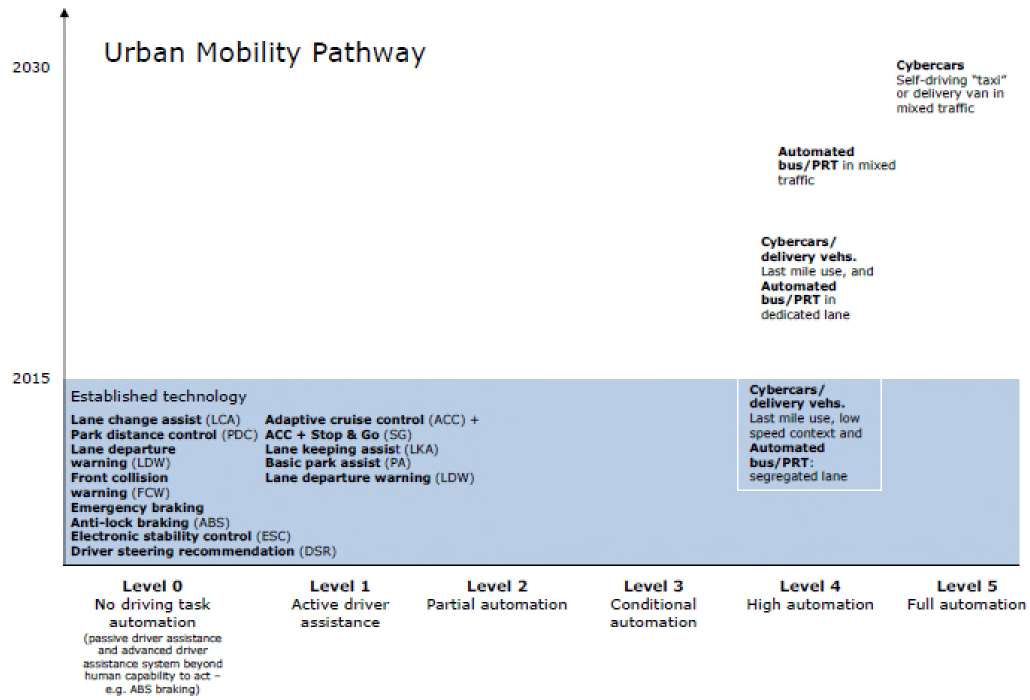


Figure A4.9 Deployment by Level of Automation (Transit)

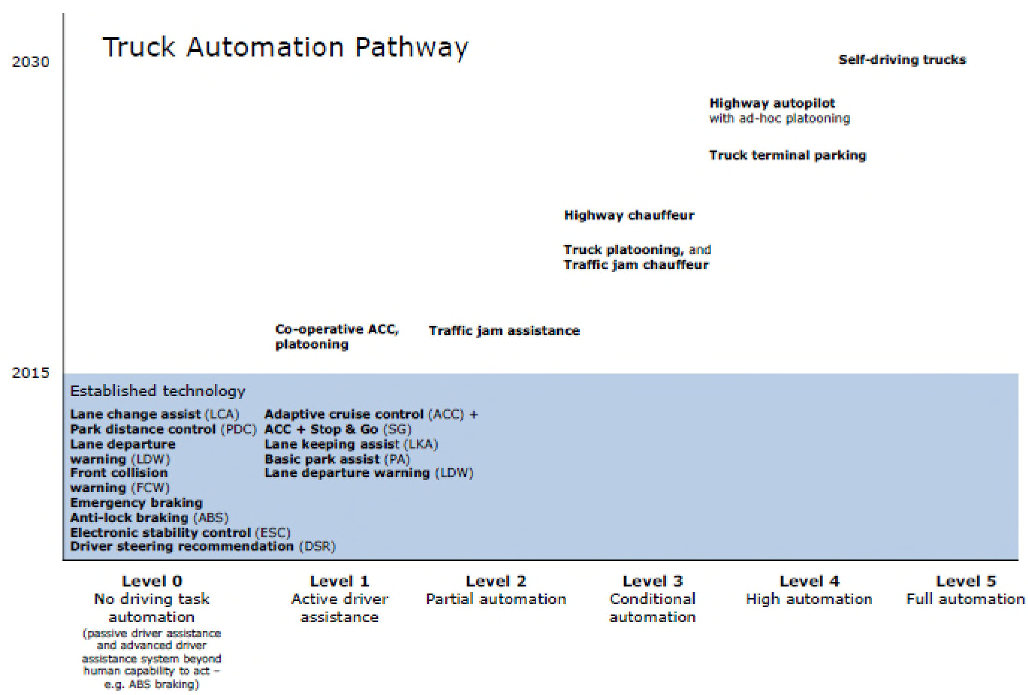


Figure A4.10 Deployment by Level of Automation (Freight)

APPENDIX 5: USER PERCEPTION AND ADOPTION

Since the AV is a relatively new technology with most of the public having no practical exposure to it, it is very important to understand public perceptions. Such an effort helps in (1) assessing knowledge/misconceptions in people, (2) determining peoples' intent to use, (3) better predictions of market penetration rates, and (4) for defining the role of public education. There have been several surveys of public perceptions conducted in the past few years. These surveys have been conducted by a variety of agencies such as technology companies, auto insurance companies, and academic institutions. In the rest of this chapter, we present a short summary of findings from across these surveys. We limit the focus to the American context as some of these surveys also look at global perceptions. We also focus on fully autonomous vehicles that are essentially NHTSA levels 3 and 4 of automation. The summary of perceptions is presented by addressing three questions (1) Decision to Own an Autonomous Vehicle, (2) Decision to Ride in an Autonomous Vehicle, and (3) Decision to let others ride in an Autonomous Vehicle. The results presented in this section are synthesized from several surveys[1].

Decision to own autonomous vehicles: Perceptions about owning an autonomous vehicle is important as it is in line with the current model of vehicle ownership. Overall, on averaging across several surveys, about 20-40% of survey respondents indicate that they are favorable to owning an automated vehicle. Those who were more favorable towards ownership include younger persons, males, higher educated persons, and urban residents. In contrast, older people, females, lower education persons and rural residents generally show a lower favorability towards ownership. It is also useful to note that not all surveys assessed whether the respondents had any familiarity with the technology. Those that did assess familiarity, report that people with greater familiarity are more favorable to ownership. Finally the cost of these autonomous vehicles were not made explicit in many surveys either. It is also useful to note that the University of Michigan survey showed that people were generally not willing to pay anything extra for this advanced technology. Among those surveys that did address costs, we observe that the likelihood of owning an autonomous vehicle decreased when additional costs of ownership were made explicit and increased when monetary benefits in the form of reduced insurance premiums were made explicit. Finally, none of these studies examined when someone would buy an automated vehicle. However, the study by

[1] http://www.tyrepress.com/2014/07/driverless-cars-survey-says-no-thanks/
http://www.carinsurance.com/Articles/autonomous-cars-ready.aspx
http://www.insurance.com/auto-insurance/claims/autonomous-cars-self-driving.html
http://www.forbes.com/sites/jimgorzelany/2013/09/23/most-consumers-say-theyll-snub-self-driving-cars-survey-says/
http://cdn3.vox-cdn.com/assets/4840208/UMTRI-2014-21.pdf
http://deepblue.lib.umich.edu/bitstream/handle/2027.42/109433/103139.pdf
https://pictures.dealer.com/jdpower/efd04f1a0a0d02b700ad8bb40bba5337.pdf
http://autos.jdpower.com/content/study-auto/lN3SbRs/2014-u-s-automotive-emerging-technologies-study-results.htm
http://www.jdpower.com/press-releases/jd-power-reports-vehicle-owners-willing-pay-smartphone-functionality-not-connectivity
http://www.danielledai.com/academic/howard-dai-selfdrivingcars.pdf
http://www.wpi.edu/Pubs/E-project/Available/E-project-043013-155601/unrestricted/A_Study_of_Public_Acceptance_of_Autonomous_Cars.pdf

WPI indicates that more than 60% of the people are likely to buy 3+ years after the availability of the technology.

Decision to ride autonomous vehicles: A future of shared mobility in which autonomous vehicles are not owned by individuals but simply called when trips need to be made is also routinely postulated. Therefore, it is also of interest to see whether people would be interested in riding in such vehicles even if they do not necessarily own them. Overall, on averaging across several surveys, about 50-70% of survey respondents indicate that they are favorable to riding in an autonomous vehicle. Notice that these estimates are larger than the fraction of people (20-40%) who were willing to own autonomous vehicles. Factors such as higher education and urban location were correlated with a greater preference for riding in autonomous vehicles. Finally, a Berkeley Study also indicates that about 17% of the people would be taking 4+ trips in a "self-driving taxi" with the rest taking fewer trips suggesting that the autonomous vehicle may not immediately replace all travel.

Decision to let others ride autonomous vehicles Autonomous vehicles have the promise of providing independent mobility to segments of population such as children, elderly, and the disabled. Therefore, it is also of interest to see if people would be willing to let "loved ones" ride the autonomous vehicles by themselves. Again, on averaging across several surveys, about 25-45 % of survey respondents indicate that they are favorable to letting kids/elderly ride in an autonomous vehicle by themselves. Notice that these estimates are smaller than the fraction of people (50-70%) who were willing to ride themselves.

Overall, there is much variability in users' willingness to adopt autonomous vehicles as a mode of transportation. While people report a greater willingness to ride an autonomous vehicle, the willingness to own one or allow others to ride in one is much lesser. Much of the variability across these surveys could be ascribed to various factors. Several different entities including private-sector companies and academic institutions have conducted these surveys and the former generally provide little details about the survey methods and sample compositions. The sample size of these surveys range from 100s – more than 17,000. The surveys did not measure perceptions on similar scales. Most of these surveys were on-line and/or phone surveys and the respondents' familiarity with the autonomous vehicles is generally not known even though they were being asked to report their willingness to use that technology. The surveys generally did not make the costs or benefits explicit.

Despite the issues associated with existing surveys, the fact remains that the results of these surveys are indeed broadcasted to the public via various means. For example, results of surveys undertaken by University of Michigan (reported in press in May 2016) indicate that the highest preference by motorists is for "non- self-driving car"[1]. A June 2016 article based on a survey conducted by Volvo was published with a headline of "**Volvo Survey: Californians and New Yorkers want autonomous cars;** On the flip side Texas and Philadelphians are still skeptical" {emphasis retained from original headline}[2]. Another article also from June 2016 based on the results of a survey by Alexis Partners indicate that "three quarters of respondents fully support autonomous vehicles"[3]. Further the results from various surveys are disseminated

[1] http://www.umich.edu/~umtriswt/PDF/SWT-2016-8_Abstract_English.pdf
[2] http://www.autoblog.com/2016/06/29/volvo-survey-californians-new-yorkers-want-autonomous-cars/
[3] http://fortune.com/2016/06/30/self-driving-car/

independent of each other and, therefore, all people may not be seeing the same "results" or "conclusions". Therefore, the state agency has an important role to play in synthesizing such knowledge and presenting to its constituents. This will be important in educating the public and shaping public perception about the subject. Further, there is also a continued need to conduct further perception studies using larger samples, better techniques, and as a panel study to understand the evolution of perceptions over time.

APPENDIX 6: AV IMPACTS ON TRAVEL DEMAND AND SYSTEM PERFORMANCE

The impacts of AV on travel demand and system performance is still largely speculative with relatively few empirical/simulation studies. A variety of hypotheses have been proposed considering the marginal effects of each of several aspects of AV on travel demand and some of these are presented next (these are drawn from a variety of sources)[1].

- AVs can increase roadway capacity because of shorter headways and higher speeds
- AVs in a mixed fleet can decrease roadway capacity because of the interactions between autonomous and non-autonomous vehicles
- AVs can improve travel time reliability because of reduced crashes leading to less likelihood of non-recurrent congestion
- AVs can decrease trip length/ VMT/VHT as the vehicles may be able to dynamically choose faster paths
- AVs can increase trip lengths as time spent in the vehicle can be spent usefully and travel becomes less onerous.
- AVs can increase overall number of trips as it provides mobility options to previously mobility-constrained populations such as elderly, and disabled
- AVs reduce the need for parking, facilitate drop-offs close to destination and reduce out-of-vehicle travel times.
- AVs may be traveling in the network as ZOV (zero occupant vehicles) as they go pick up their next passenger or go to a parking spot after a drop off leading to additional dead mileage on the roads.
- The per-trip travel costs of AV may be higher (higher cost of vehicle, shared mobility models) leading to fewer trips and shorter distances
- The per trip travel costs of AV may be lower (higher fuel efficiency because of smoother driving, possible electrification of the fleet) leading to more and/or longer trips.
- As AVs can lead to lower values of travel time and longer trips, this can lead to urban sprawl

[1] http://www.automatedvehicleinstitute.org/pdf/TAVI_8-CapacityPinjari.pdf
Srinivasan, S., Smith, S., Milakis, D. (2015) Implications of Vehicle Automation for Planning Road Vehicle Automation 3, G. Meyer and S. Beiker (eds.),pp 287-295 Lecture Notes in Mobility, DOI 10.1007/978-3-319-40503-2_23
http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR443-2/RAND_RR443-2.pdf
http://static.tti.tamu.edu/swutc.tamu.edu/publications/technicalreports/600451-00029-1.pdf
http://onlinepubs.trb.org/onlinepubs/conf/CPW19.pdf (pages 42-46)
http://www.wsp-pb.com/Globaln/USA/Transportation%20and%20Infrastructure/driving-towards-driverless-WBP-Fellow-monograph-lauren-isaac-feb-24-2016.pdf
https://www.enotrans.org/wp-content/uploads/2015/09/AV-paper.pdf
http://trrjournalonline.trb.org/doi/abs/10.3141/2422-13
http://www.vtpi.org/avip.pdf
http://www.automatedvehicleinstitute.org/pdf/TAVI_1-PublicTransitPolzin.pdf

- If the AVs develop as a shared mobility option, they may not be cost effective in a sprawled setting leading to an implicit encouragement of more compact developments
- AVs can reduce market shares of walking and biking if they are available as a shared mobility options at a low costs
- AVs can reduce the market share of transit especially if they are available as a shared mobility options at a low costs
- AVs can vastly improve the access and egress to mass transit and could increase the market shares of premium transit modes such as bus rapid or rail
- In a shared mobility world, the AVs could effectively become the new "transit" requiring re-labeling of conventional modal classifications
- AVs could provide the "last-mile" solution for urban freight deliveries thereby improving the efficiency of freight movements.

As is evident from the list, the speculated effects are also often contradictory because of differential assumptions made about the costs, levels of market penetration etc. Although there are few empirical studies that often rely on simulation-based approaches, it can be argued that there are no conclusive evidences supporting or disproving any of these hypotheses. Lack of data is a certainly a critical reason for the lack of empirical studies. It is acknowledged that research aimed at understanding the behavioral impacts of AV is in its infancy and much needs to be done[1][2][3].

The rest of this appendix presents an overview of efforts that have examined the impacts of AV on travel demand patterns by tweaking key parameters in existing travel forecasting model structures to potentially mimic one/more effects of AV. It is useful to acknowledge that none of these efforts have considered all possible effects of AV on travel behavior changes (as is also recognized by the authors of the respective studies). As such these results should not be viewed as definitive impacts; rather these studies provide primary insights into the capabilities and inadequacies of the current modeling paradigm and can be used to develop appropriate modeling approaches to forecast demand in an AV world.

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[1] Scott Smith, Jeffrey Bellone, Stephen Bransfield, Amy Ingles, George Noel, Erin Reed, and Mikio Yanagisawa (2015) Benefits Estimation Framework for Automated Vehicle Operations, FHWA-JPO-16-229

[2] http://static.tti.tamu.edu/swutc.tamu.edu/publications/technicalreports/600451-00029-1.pdf

[3] http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(98)_RoadmapTopics_Final.pdf

The Puget Sound Modeling Effort[1]:

This study used Puget Sound region's activity-based demand model Sound Cast (based on the DaySim platform) for the year 2010 and explored potential impacts of AV under four scenarios by tweaking

- roadway capacity (30% increase to reflect better platooning because of shorter headways and reduced non-recurring congestion because of decreased crashes), [Scenario 1,2,3]
- value of travel time for high income households (65% decrease to reflect that travel time may be perceived to be less onerous by the early adopters who are likely to be richer) , [Scenario 2]
- value of travel time for all households (65% decrease to reflect that travel time may be perceived to be less onerous by all under full market penetration levels), [Scenario 3]
- reduced parking costs (50% decrease because of increased efficiency of parking), [Scenario 3]
- and increased travel cost ($1.65/mile - no personal auto ownership, it is treated as a service for hire with rates similar to those charged by TNCs). [Scenario 4]

Scenarios 1 and 2 resulted in increased VMT (increased efficiency/capacity and travel time perceived to be less onerous leading to longer trips) it also resulted in decreased VHT (even though more travel is happening, it is taking place at higher speeds). Scenario 3 resulted in increased VMT and VHT as this scenario assumes full market penetration of AV and reduced value of travel time for the entire population and reduced parking costs. Finally, Scenario 4, which represents an increased travel cost only (with no changes to capacity, parking costs or value of time) resulted in significantly decreased VMT and VHT as the marginal cost of travel is increased manifold compared to base conditions.

The Atlanta Study[2]

The Atlanta study used its activity based model for the year 2040 to study the impacts of a fully automated future with 100% market penetration. Four scenarios were considered

- Increased capacity (doubled)
- Increased capacity (doubled) and reduction in value of travel time (50% decrease)
- Increased capacity (doubled), reduction in value of travel time (50% decrease), and reduction in vehicle operating costs (71% reduction in fuel efficiency)
- Increased capacity (doubled), reduction in value of travel time (50% decrease), and reduction in vehicle operating costs (71% reduction in fuel efficiency), and parking costs (reduced to 0)

The scenarios generally yielded increased trip lengths and trip frequencies. With the exception of the first scenario (capacity increase only) all others yielded an increase in VHT. At the same time all scenarios also indicated a decrease in delay suggesting that the increased travel is still taking

[1] http://psrc.github.io/attachments/2014/TRB-2015-Automated-Vehicles-Rev2.pdf
[2] https://www.pcb.its.dot.gov/t3/s151119/s151119_Road_Transport_Automation_presentation_JohnOrr.pdf

place at possibly higher speeds. Finally, the study also indicated a decrease in the share of transit trips with the increased convenience offered by the AVs (the study however did not consider any changes to transit service characteristics or the possibility of increased use of AV as access modes to transit).

The San Francisco Bay Area Studies[1,2]

There are two reported studies that have used the CT-RAMP activity-based model for San Francisco Bay area to study the effects of AV.

In the first study, the model was modified by adjusting the capacity values of the roadway facilities to explore the effects of vehicle automation. No other changes in parameters were considered in this exercise. Four levels of capacity changes were examined

- Capacity of freeways increased by a factor of 1.5 and capacity of major arterials increased by a factor of 1.2
- Capacity of freeways increased by a factor of 2 and capacity of major arterials increased by a factor of 1.4
- Capacity of freeways increased by a factor of 2.5 and capacity of major arterials increased by a factor of 1.6
- Capacity of freeways increased by a factor of 3 and capacity of major arterials increased by a factor of 1.8

The simulations show an increase in trip frequency and VMT but the congested speeds on some of the key facilities (the bridges across the bay) increased with increased capacity. Not much change was observed on other aspects of travel demand. In the second study, both roadway capacity and value of travel time were modified. Two levels of capacity increases were considered (10% and 100%) and two levels of value of travel time were considered (comparable to that of a high quality rail and ½ the current value of auto travel time). As in the case of previous studies, the scenarios generally yielded an increase in VMT.

Miami Study[3]

In an on-going study in the Miami region in Florida, alternate scenarios of AV futures are being examined along the lines of previous work in Puget Sound, Bay Area, and Atlanta. Specifically, models will be tweaked to reflect capacity increases (80-100% for freeways and 10-30% for other facilities), reduction in the value of travel times (5-10%), decreased parking costs (20% reduction) and reduced out of vehicle travel times because of closer drop-offs (terminal times set to 1 minute). The results from these simulation studies are not yet available.

[1] Chapter 6 of http://analytics.mtc.ca.gov/foswiki/pub/Main/Documents/2013_06_27_RELEASE_DRAFT_Sensitivity_Testing.pdf

[2] https://higherlogicdownload.s3.amazonaws.com/AUVSI/c2a3ac12-b178-4f9c-a654-78576a33e081/UploadedImages/documents/pdfs/7-16-14%20AVS%20presentations/Michael%20Gucwa.pdf

[3] Evans (2016) Emerging Technology, Demographic Changes and Travel Behavior, presentation made the Model Advancement Committee of the Florida Model Task Force, February 22, 2016

APPENDIX 7: FLORIDA LEGISLATION

The recently enacted HB 7061 stipulates that the Long Range Transportation Plans (LRTPs) in Florida consider the infrastructure changes needed to accommodate advanced vehicle technologies such as autonomous vehicles. This is indeed historic in that it represents one of the first mandates of a state legislation that autonomous vehicles be included in long range transportation planning. The relevant portion of the bill is provided below[1]

The long-range transportation plan must, at a minimum:

(c) Assess capital investment and other measures necessary to:

1. Ensure the preservation of the existing metropolitan transportation system including requirements for the operation, resurfacing, restoration, and rehabilitation of major roadways and requirements for the operation, maintenance, modernization, and rehabilitation of public transportation facilities; and

2. Make the most efficient use of existing transportation facilities to relieve vehicular congestion, improve safety, and maximize the mobility of people and goods. Such efforts must include, but are not limited to, consideration of infrastructure and technological improvements necessary to accommodate advances in vehicle technology, such as autonomous technology and other developments.

This bill also requires autonomous vehicle technology in the Strategic Intermodal Systems Plan. The relevant portion of the bill is provided below[2] ()

The department shall coordinate with federal, regional, and local partners, as well as industry representatives, to consider infrastructure and technological improvements necessary to accommodate advances in vehicle technology, such as autonomous technology and other developments, in Strategic Intermodal System facilities.

The Strategic Intermodal System Plan shall include the following:

A needs assessment that must include, but is not limited to, consideration of infrastructure and technological improvements necessary to accommodate advances in vehicle technology, such as autonomous technology and other developments.

In addition to the above, the bill also makes the following statutory changes regarding the operation and regulation of autonomous vehicles[3]

- Clarifying that the authorization for a person holding a valid driver license to operate an autonomous vehicle applies on the public roads of this state.
- Revising provisions regarding the operation of autonomous vehicles on roads for testing purposes.

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[1] §239, Fl. Stat. (2016). http://laws.flrules.org/2016/239 (CHAPTER 2016-239 pp. 51-52)
[2] §239.47, Fl. Stat. (2016). http://laws.flrules.org/2016/239 (CHAPTER 2016-239 pp. 53)
[3] summary reproduced from: https://www.flsenate.gov/Committees/billsummaries/2016/html/1354

- Revising equipment requirements for autonomous vehicles, requiring a system to alert an operator of a technology failure and to take control, or to stop the vehicle under certain conditions.
- Prohibiting operation of a motor vehicle on the highways of this state while the vehicle is in motion if the vehicle is actively displaying moving television broadcast or pre-recorded video entertainment content visible from the driver's seat, unless the vehicle is equipped with autonomous technology and is being operated in autonomous mode.
- Providing that an electronic display used by an operator of a vehicle equipped with autonomous technology or by an operator of a vehicle equipped with driver-assistive truck platooning technology is not prohibited.
- Defining the term "driver-assistive truck platooning technology;" requiring the FDOT to study, in consultation with the FDHSMV, the use and safe operation of driver assistive truck platooning technology; and authorizing a pilot project to test vehicles equipped with such technology.
- Requiring manufacturers of such technology to provide insurance before the start of the pilot project and requiring the FDOT, in consultation with the FDHSMV, to report the results of the study and any findings or recommendations from the pilot project.