Transportation Consortium of South-Central States

Tran-SET

Solving Emerging Transportation Resiliency, Sustainability, and Economic Challenges through the Use of Innovative Materials and Construction Methods: From Research to Implementation

Analysis, Modeling, and Simulation (AMS) Case Studies of Connected and Automated Vehicle (CAV) Implementations Specific to the South Central Region

Project No. 19ITSLSU06

Lead University: Louisiana State University

Final Report

May 2021

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation's University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.

Acknowledgements

This was work was supported by contributions from PTV Group, Capital Regional Planning Commission, and Louisiana State University. The authors would also like to thank members of the Project Review Committee for their support and direction: Akhil Chauhan (Arcadis), Stephen Glascock (LaDOTD), Jamie Setze (CRPC), Alaa Shams (LaDOTD), and Kuilin Zhang (Michigan Tech).

TECHNICAL DOCUMENTATION PAGE

1. Project No.	2. Government Accession No.	3. Recipient's Catalog No.
19ITSLSU06		

4. Title and Subtitle Analysis, Modeling, and Simulation (AMS) Case Studies of Connected and Automated Vehicle (CAV) Implementations Specific to the South Central Region	**5. Report Date** May 2021 **6. Performing Organization Code**
7. Author(s) PI: Christopher Melson https://orcid.org/0000-0002-9439-0278 Consultant: Jiaqi Ma https://orcid.org/0000-0002-8184-5157	**8. Performing Organization Report No.**
9. Performing Organization Name and Address Transportation Consortium of South-Central States (Tran-SET) University Transportation Center for Region 6 3319 Patrick F. Taylor Hall, Baton Rouge, LA 70803	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** 69A3551747106
12. Sponsoring Agency Name and Address United States of America Department of Transportation Research and Innovative Technology Administration	**13. Type of Report and Period Covered** Final Research Report Aug. 2019 – May 2021 **14. Sponsoring Agency Code**

15. Supplementary Notes

Report uploaded and accessible at Tran-SET's website (http://transet.lsu.edu/).

16. Abstract

Connected and automated vehicles (CAVs) offer potentially transformative and far-reaching impacts to the transportation system. However, realized benefits will be directly tied to how well agencies prepare for these technologies. This report documents efforts that support CAV preparatory actions in Louisiana and includes: (1) conducting a stakeholder survey to inform engagement activities to develop strategic partnerships in CAV deployment and (2) conducting crash analyses for deployment scenarios of CAV-based queue warning systems (QWSs).

An electronic survey was developed and disseminated to 273 Louisiana organizations. The purpose of the survey was to engage these organizations under the context of CAV planning and gauge their awareness, perception, and viewed importance of planning for CAV technologies. Survey results were clustered in three main groups: Group A—those uninformed of CAV technologies and do not believe they will impact their organization, Group B—those more informed but also do not believe their organization will be impacted, and Group C—those aware, positively perceive, and believe it is important to prepare. Results indicate a strong correlation between the level of awareness and perception of CAV technologies. Low awareness and perception by economic development, freight, and transit groups indicate areas of concern. Survey results were further analyzed utilizing a CAV-specific capability maturity framework, and recommendations were developed to engage stakeholders in planning efforts.

A crash analysis was conducted at four proposed locations across Louisiana to determine QWS suitability. The analysis utilized five-year historical crash data and focused on crash rate, severity level, manner of collision, and level of service of safety. Due to overrepresented rear-end crashes, QWSs may be suitable at the Jefferson Parish and West Baton Rouge Parish locations.

Each effort was prepared to be general and beneficial to transportation agencies involved in similar CAV activities.

17. Key Words	18. Distribution Statement
Connected and automated vehicles; Survey; Public agency collaboration; Queue warning systems; Crash analysis	No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	49	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized.**

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^{o}F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^{o}C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m	square meters	10.764	square feet	ft^2
m	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m	cubic meters	35.314	cubic feet	ft^3
m	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
C	Celsius	1.8C+32	Fahrenheit	^{o}F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AADT	Annual Average Daily Traffic
AMS	Analysis, Modeling, and Simulation
AV	Autonomous Vehicle
CAV	Connected and Automated Vehicle
CMF	Capability Maturity Framework
CMM	Capability Maturity Model
COA	Council on Aging
CV	Connected Vehicle
DOT	Department of Transportation
FHWA	Federal Highway Administration
F&SI	Fatal and Serious Injury
LaDOTD	Louisiana Department of Transportation and Development
LOSS	Level of Service of Safety
QWS	Queue Warning System
SPF	Safety Performance Function
TSMO	Transportation Systems Management and Operations
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything

EXECUTIVE SUMMARY

Connected and automated vehicles (CAVs) offer potentially transformative and far-reaching impacts to the transportation system—and other associated, reliant fields. However, realized benefits will be directly tied to how well public agencies prepare for these technologies. The original intent of this study was to conduct analysis, modeling, and simulation (AMS) case studies of CAV deployment strategies of importance and specific to the South Central region. The study was later expanded to better coordinate and assist with initiatives led by the Louisiana Department of Transportation and Development's (LaDOTD's) "CAV Technology Team". This expansion included:

1. Conducting a broad stakeholder survey (with accompanying analysis) to inform engagement activities in developing strategic partnerships for successful CAV deployment;
2. Conducting crash analyses of specific CAV deployment scenarios (as chosen by the Team and documented in their CAV Action Plan); and
3. Providing recommendations to conduct AMS case studies that would support the Team (and similar programs at other transportation agencies).

Stakeholder Survey: A brief electronic survey was developed and disseminated to 273 Louisiana organizations. The main purpose of the survey was to: (1) initially engage these organizations, (2) gauge their current awareness, perception, and viewed importance of planning for CAV technologies, and (3) identify areas of concern. In total, 117 participants completed the survey, including representatives from 57 local agencies, 19 state agencies, 5 federal agencies, 24 nonprofits, and 12 private companies. Participants were organized by functional category: advocacy groups, aging communities, disadvantaged groups, economic development, environmental quality, freight, planning, public safety, traffic operations, and transit.

Survey responses were clustered in three main groups: Group A (aging communities, disadvantaged groups, economic development, and freight) are those uninformed of CAV technologies and do not believe they will impact their organization, Group B (advocacy groups, environmental quality, and transit) are more informed but also do not believe their organization will be impacted, and Group C (planning, public safety, and traffic operations) are aware, positively perceive, and believe it is important to prepare for CAV technologies. Overall, there was a statistically significant relationship between the level of awareness and perception of CAV technologies (i.e., higher awareness leads to a more positive perception of CAV technologies). Low awareness and perception by economic development, freight, and transit organizations may be an area of concern—especially considering the low levels of perceived impact and importance of planning by freight and transit operators. 22.2% of responded organizations are currently preparing for CAV technologies, with wide variability by agency type: 100% of responded federal agencies are, 50% of private companies, 21.1% of state agencies, 15.8% of local agencies, and 8.3% of nonprofits.

Utilizing survey results and a CAV-specific capability maturity framework, a list of recommend actions was developed for LaDOTD to foster and sustain key partnerships in developing a successful CAV program. Recommendations included: establishing an external CAV advisory council and forum, creating stakeholder outreach plans with an educational component tailored to the organization's awareness level, conducting a knowledge, skills, and abilities (KSA) gap analysis and inventory of partner strengths, and conducting pilot projects to strategically target key stakeholders.

Crash Analysis: Due to its prevalence in the CAV Action Plan, queue warning systems (QWSs) were chosen for further analysis. A crash analysis was conducted at each location specified in the Plan to determine if the proposed deployment scenarios are suitable candidates for QWS. The analysis utilized five-year historical crash data and focused on crash rate, severity level, manner of collision, and level of service of safety. The analysis was conducted in accordance with LaDOTD guidelines—and included the following locations: (1) a 4.5-mi segment of I-110 near the Governor's Mansion in East Baton Rouge Parish, (2) a 9.3-mi segment of I-10 near Louis Armstrong New Orleans International Airport in Jefferson Parish, (3) a 12.5-mi segment of I-10 in West Baton Rouge Parish, and (4) a 15.3-mi segment of I-12 in St. Tammany Parish. Primarily due to overrepresentation of rear-end crashes, QWSs may be suitable at the Jefferson Parish and West Baton Rouge Parish locations.

AMS CAV Case Study: The research team solicited, obtained, and reviewed several existing modeling networks for the purpose of conducting AMS CAV case studies. Those reviewed were not suitable mainly due to their limited geospatial coverage. Likewise, after discussions with LaDOTD staff, it was not recommended to apply these models outside of their original purpose. The research team identified an existing microsimulation model (independent of those developed through a LaDOTD contract) of I-10 at the Mississippi River Bridge in Baton Rouge. Due to significant recurring congestion and series of complicated entrances/exits, the network is ideal for investigating various mobility-based CAV applications.

In this study, the State of Louisiana and LaDOTD was used as a case study—representing agencies with no deployment experience who are currently investigating CAV technologies and beginning planning efforts. Although brief and with limitations, it is our hope results will be utilized in current and future CAV preparatory actions—informing CAV-related policy, planning, and integration strategies at similar transportation agencies.

1. INTRODUCTION

Connected and automated vehicle (CAV) technologies offer potentially transformative and far-reaching impacts to the transportation system—and other associated, reliant fields. This may include impacts to public safety, congestion, personal mobility, land use, pollution and the environment, socio-economic characteristics, and the economy. However, realized benefits will be directly tied to how well public agencies prepare for these emerging technologies, including their ability to (1) involve and coordinate across disciplines and governing bodies and (2) evaluate impacts of CAV implementations.

Due to uncertainty in the technological capabilities, when the technology may be fully developed, its market adoption, and infrastructure requirements, it is difficult for state departments of transportation (DOTs) to estimate such benefits and better prepare their transportation system to maximize such benefits. National guidance *(1)* has been developed to aid state DOTs in assessing CAV-related policy, planning, and integration strategies; but these strategies are general and may not be applicable to the transportation issues facing each state. To properly evaluate the impacts of deploying CAV applications, state DOTs must be able to effectively and fully quantify the impacts of such deployments and identify which application best addresses their unique transportation problem.

Traffic analysis, modeling, and simulation (AMS) tools provide an efficient means to evaluate transportation improvement projects prior to deployment. In fact, the FAST Act dictates utilizing AMS tools "to the fullest and most economically feasible extent practicable" to analyze highway and public transportation projects *(2)*. Traditional AMS tools are not well-suited for evaluating CAV applications due to their inability to incorporate vehicle connectivity/communication and automated features. However, the research community has recognized this research gap and developed several traffic models (e.g., car-following models) replicating the operation and performance of a CAV. Likewise, the Federal Highway Administration (FHWA) has recently funded a series of (in-progress) research projects *(3-5)* to develop and validate AMS models for the most prominent CAV applications.

Although there is a vast amount of CAV deployment activities nationally and internationally—including many directly involving state DOTs—the majority of state DOTs have not conducted deployments nor other CAV planning initiatives (see Figure 5). In one aspect, these state DOTs can be viewed as "late majority" or "laggards" on a standard technology adoption curve—such as the highly referenced curve by Rogers *(6)*. However, the interaction of internal and external forces, organizational culture, and resource allocation—and their influence in the decision for public agencies to promote specific technologies and processes—is extremely complex. Agencies can still greatly benefit from continued research and other efforts that assist in establishing successful CAV programs.

As it relates to preparing for and adopting CAV technology, four of the five states in Region 6 (AR, LA, NM, and OK) can be considered early or late majority adopters—and have taken a more "reactive" approach in their preparation strategies. However, it is clear they are still interested in exploring how CAV applications can benefit their transportation systems.

This study documents a variety of efforts that support CAV preparatory actions in Louisiana—with the intent of each effort being beneficial to other local and state DOTs involved in similar activities. These efforts include: (1) conducting a broad stakeholder survey (with accompanying analysis) to inform engagement activities in developing strategic partnerships for successful CAV deployment, (2) conducting basic crash analyses for select CAV case studies, and (3) building upon the previous efforts, providing recommendations in conducting a small-scale AMS CAV case study.

2. OBJECTIVES

The original intent of this study was to conduct AMS case studies of CAV deployment strategies of importance and specific to the South Central region—as to supplement and better inform CAV-related policy, planning, and integration strategies being developed by DOTs. However, the study was expanded to better coordinate with initiatives led by the Louisiana Department of Transportation and Development's (LaDOTD's) "CAV Technology Team" *(7)*—and to supplement, improve, and better focus their planning efforts. It is believed this new direction will provide a greater benefit to DOTs currently exploring CAV technologies and better fulfil Tran-SET's mission *(8)* of supporting implementation. Likewise, it overcomes the obstacles encountered that significantly reduced the original envisioned benefit (see Subsection 4.3 for details).

The main objectives of this study are to:

1. Survey a diverse group of Louisiana organizations whose purview may be impacted by CAV technologies to:
    a. Initially engage these organizations under the context of CAV planning;
    b. Gauge their awareness and perception of CAV technologies, likelihood of impacts, and importance in preparing for such technologies; and
    c. Identify areas requiring further action (e.g., identify organizations to be involved in State preparatory initiatives, identifying organizations where education is warranted, etc.).
2. Analyze survey results utilizing a CAV-specific capability maturity framework (CMF) to develop a list of recommendations to engage stakeholders in planning activities.
3. Conduct crash analyses on specific CAV deployment scenarios (as chosen by the "CAV Technology Team" and documented in their CAV Action Plan).
4. Provide recommendations to conduct AMS case studies that would support the "CAV Technology Team" (and similar programs at other local and state DOTs).

3. BACKGROUND

CAV technology is a broad term encompassing a wide-range of both communication devices/protocol (e.g., dedicated short range communications (DSRC), 4G-LTE, and Wi-Fi) and vehicular automated features. It includes purely connected vehicle (CV) applications utilizing V2X communication (vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian); as well as applications with varying levels of automation. Figure 1 provides an illustrative list of CV applications. Queue warning systems (QWSs) are listed under mobility, but can also be considered a safety application.

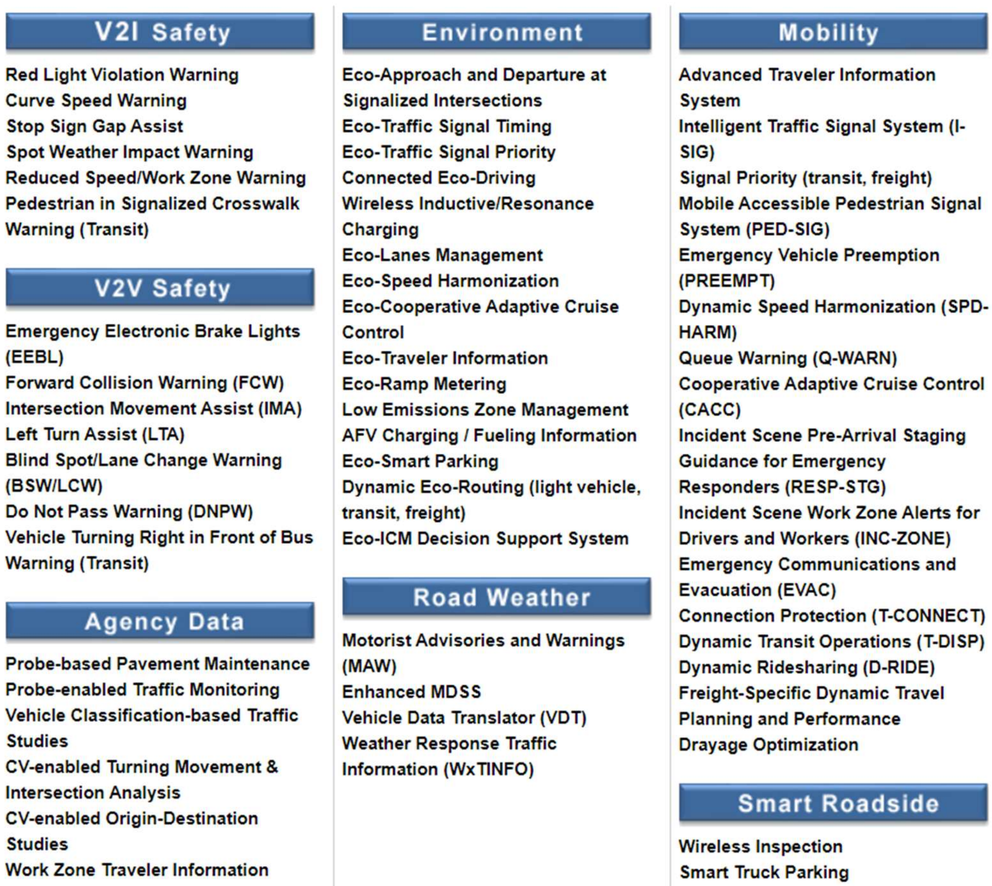


Figure 1. List of CV applications *(9)*.

Figure 2 shows the most universally recognized levels of automation as defined by the Society of Automotive Engineers (SAE) International *(10)*. Significant mobility, safety, and environmental benefits can be achieved by integrating communication and automated features together, even at low automation levels (such as SAE level 1 with longitudinal automation). Example applications, include: cooperative adaptive cruise control (CACC), truck platooning, cooperative speed harmonization, cooperative on-ramp merging, lane speed monitoring schemes, platoon-based intersection management, and advanced traffic signal coordination. Figure 3 highlights applications currently being developed and field tested by FHWA.

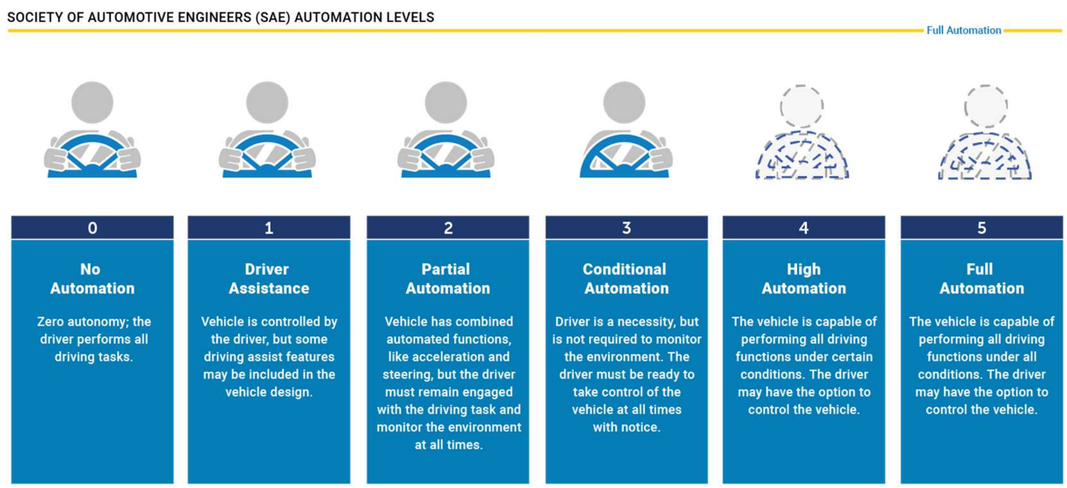


Figure 2. SAE levels of automation *(10)*.

Figure 3. Examples of CAV applications with low automation levels: (a) truck platooning *(11)*, (b) cooperative merging *(12)*, (c) signalized intersection approach and departure *(13*), and (d) CACC *(14)*.

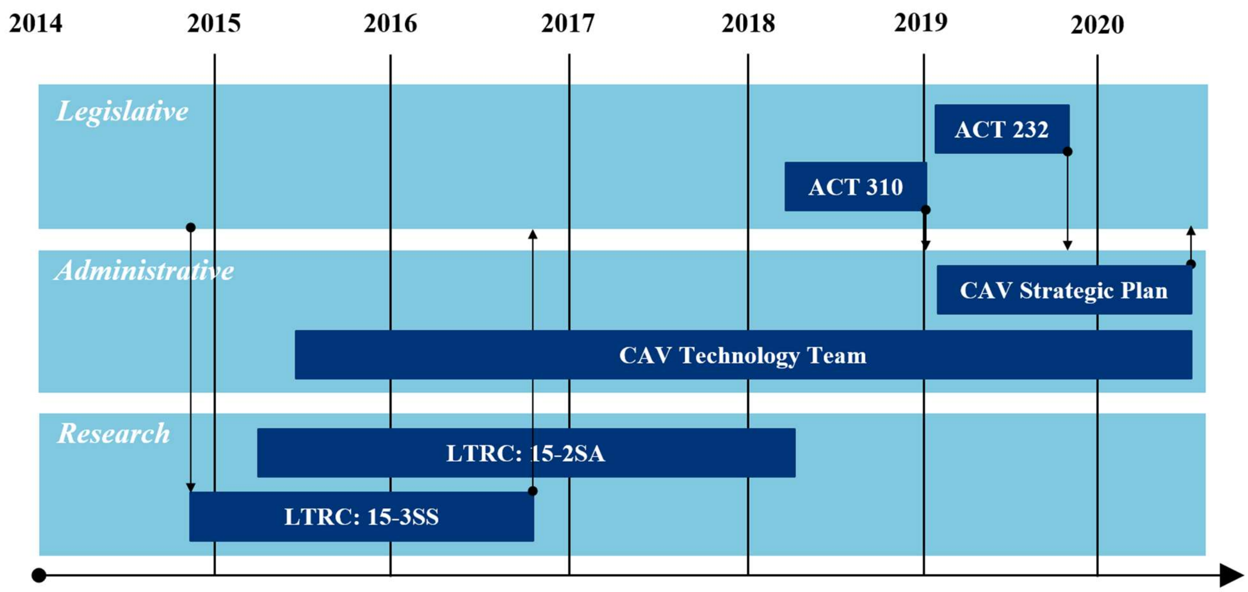
The following Subsections provide additional background information categorized and specific to each study effort: the stakeholder survey and crash analysis.

3.1. Stakeholder Survey

To provide appropriate context in interpreting the survey results, recommended actions, and the CAV CMF evaluation, this Subsection provides an overview of current CAV-related preparatory actions in Louisiana. It also briefly reviews and categories CAV efforts at all other state DOTs as to properly present Louisiana as a case study. Lastly, it introduces the transportation systems management and operations (TSMO) CMM—which forms the basis of the CAV CMF.

3.1.1. CAV-Related Preparatory Actions in Louisiana

The main CAV preparatory actions taken by Louisiana entities are summarized in Figure 4 and categorized by research, administrative, and legislative affiliations. Although several actions have been conducted in isolation, arrows depict high-level relationships between initiatives.



LTRC: 15-3SS = "Legislative Action Needed to Accommodate the Future Safe Operation of Autonomous Vehicles in the State of Louisiana" *(15)*; **LTRC 15-2SA** = "Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator" *(16)*; **CAV Technology Team** = Internal LaDOTD task force *(7)*; **CAV Strategic Plan** = LaDOTD document currently in development *(7)*; **Act 310** = Provides relative to autonomous commercial motor vehicles *(17)*; **Act 232** = Provides relative to vehicle platooning *(18)*

Figure 4. Main CAV-related preparatory actions in Louisiana.

Efforts have mainly been initiated through legislative direction. This includes the main state-associated research effort by Wilmot and Greensword *(15)*, "LTRC: 15-3SS" in Figure 4, which was prepared at the request of the Louisiana State Legislature. The report included a synopsis of AV legislation across the U.S., summarized current issues involving legislation, and recommended legislative actions to be taken by Louisiana. The synopsis included detailed recommendations, such as: distinctly demarking an AV from other vehicles, requiring $5M of liability insurance, limiting AV operation to testing, limiting AV operation during fair weather, and several other safety-related requirements.

The one other CAV-related research project, "LTRC: 15-2SA" in Figure 4, directly associated with the State of Louisiana developed a testbed for CV applications using the driving simulator at the Louisiana State University (LSU). The study developed a mechanism for the driver to receive in-vehicle warning messages based on the time-to-collision (TTC) between the virtual and simulator vehicle *(16)*. The mechanism was tested through a series of participant studies: identifying the optimal warning message, its in-vehicle location, TTC threshold, and driving population in which the warning system may be most effective in influencing behavior. To date, the developed CV environment has not been utilized in further research—and results have not been used in administrative nor legislative actions.

The administrative agency leading Louisiana in preparation of CAV technologies is the Louisiana Department of Transportation (LaDOTD). In mid-2015, LaDOTD created an internal, multidisciplinary task force, the "CAV Technology Team", with the mission to develop and maintain working knowledge of CAV technology, determine state and local transportation agency roles, formulate policy, and identify CAV applications to adopt *(7)*. The Team consists of 30 members across 25 sections/districts and has conducted regular educational meetings and internal, developmental workshops.

In early 2019, the Team initiated efforts to develop an agency-wide CAV Strategic Plan. The Plan defines LaDOTD's CAV vision, goals, and initiatives—and identifies needs to be addressed in order to implement recommended CAV strategies. It also includes a CAV Action Plan, which defines a set of 14 specific projects/actions intended to be the initial focus of a CAV program. These actions include four implementations of QWSs across the State (the most of any other listed action). To date, its development has mainly involved LaDOTD staff—with limited input from local DOTs, metropolitan planning organizations (MPOs), or other local and state agencies.

The Louisiana House of Representatives passed two significant bills regarding CAVs: Act No. 310 of the 2018 Regular Session and Act. No. 232 of the 2019 Regular Session. Act No. 310 allows for operation of vehicle-to-vehicle (V2V) based platooning on Louisiana roadways *(17)*. The Act also defines several requirements: having an operational plan approved prior to deployment, defining 400 ft as the minimum following distance for motor trucks, and prohibits platooning on two-lane highways. Act No. 232 allows operation of autonomous commercial motor vehicles without a driver present that meet specific criteria *(18)*. The criteria includes having the vehicle properly registered and titled, $2 M in liability coverage, the vehicle is capable of minimal risk if system failure occurs, among others. LaDOTD has been designated as the main agency to administer and enforce both Acts.

3.1.2. Review of Other State DOT Preparatory Actions

CAV efforts at each state DOT were reviewed and broadly categorized as in Figure 5: no CAV-related efforts, those undirected, directed, coordinated, and programmed. Efforts include any CAV-related activity with substantial involvement by the respective DOT—ranging from research projects, basic technology demonstrations, pilots, other deployments, establishing task forces, integration of CAV technologies in policy and planning documents, etc.

Undirected efforts are those not specifically directed by the DOT and where the DOT is not necessarily the main beneficiary. Examples in this category include administering AV testing programs—such as those at Idaho DOT *(19)*, Maine DOT *(20)*, Nebraska DOT *(21)*, and Vermont DOT *(22)*. Directed efforts are those directed by the DOT but are not conducted in a coordinated fashion nor whose intent is to develop a mechanism for deployment coordination. Examples of coordinated efforts include: Iowa DOT's comprehensive cooperative automated transportation (CAT) service layer plan *(23)*, Pennsylvania DOT's CAV strategic plan *(24)*, and Wisconsin DOT's Bureau of Traffic Operations CV roadmap *(25)*. Programmed efforts are not only coordinated but with intent to provide a mechanism for long-term, large-scale CAV deployment. This includes established CAV programs at Colorado DOT *(26)*, Florida DOT *(27)*, Maryland DOT *(28)*, and Virginia DOT *(29)*. A table summarizing each state DOT's actions is located in Appendix A.

Figure 5. CAV efforts at each state DOT, categorized by maturity of planning related to sustaining long-term, large scale deployment: no related efforts, those undirected, directed, coordinated, and programmed.

LaDOTD can be considered representative of agencies currently exploring CAV technologies, how they may be advantaged to improve their transportation system and user experience, have no direct deployment experience, and beginning planning efforts. It is our hope that this study is useful to those DOTs at the directed category and below.

3.1.3. TSMO Capability Maturity Model

CMM is a structured methodology to identify processes required for successful implementation of a new capability into an organization. It has been shown that DOTs who most effectively manage and operate their transportation systems are those with developed institutional processes that enable systems management (a characteristic even more important than budget levels, project types, technical ability, etc.). Based on this finding and fundamental work by Pretorius et al. *(30)* and Lockwood et al. *(31)*, the FHWA adopted CMM and applied it to the TSMO discipline—developing a TSMO-specific CMM. TSMO can generally be defined as a set of integrated strategies to optimize the operational and safety performance of existing transportation systems. Strategies comprise of multimodal, cross-jurisdictional systems, services, and projects. The TSMO CMM allows agencies to develop consensus on necessary agency improvements, identify immediate priorities to achieve these improvements, and identify specific actions to fulfil these priorities—all with the aim to continuously improve and operate a TSMO program. As shown in Table 1, the TSMO CMM comprises of 6 dimensions, each with four levels of maturity.

Agencies utilize the TSMO CMM by: (1) conducting a self-assessment to determine current capability levels, (2) identifying priority dimensions requiring immediate improvement (dimensions at the lowest level), (3) reviewing actions for each dimension, (4) selecting initial actions for the agency to pursue, and (5) compiling cross-dimensional actions into an achievable action plan. To better assist agencies in establishing TSMO capabilities, FHWA developed CMFs for six program areas: traffic management, traffic incident management, work zone management, road weather management, planned special events, and traffic signal systems management. Each CMF comprises of detailed actions and maturity level definitions tailored to their respective TSMO program area. The produced CMM and CMFs, along with corresponding guidance and support, have assisted nine state DOTs establish TSMO programs with additional TSMO programs at four state DOTs currently under development *(32)*.

Table 1. Overview of the TSMO capability maturity model *(33)*.

Dimension	Level 1 *(Exploration)*	Level 2 *(Initiated)*	Level 3 *(Integrated)*	Level 4 *(Mainstreamed)*
Business Processes *(Planning, programming, budgeting, implementation)*	Processes related to TSMO activities ad hoc and unintegrated	Multiyear statewide TSMO plan and program exists with deficiencies, evaluation, and strategies	Programming, budgeting, and project development processes for TSMO standardized and documented	Processes streamlined and subject to continuous improvement
Systems & Technology *(Systems engineering, standards, technology interoperability)*	Ad hoc approaches outside systematic systems engineering	Systems engineering employed and consistently used for ConOps, architecture and systems development	Systems and technology standardized, documented and trained statewide, and new technology incorporated	Systems and technology routinely upgraded and utilized to improve efficiency performance
Performance Measurement *(Measures, data, analytics, utilization)*	No regular performance measurement related to TSMO	TSMO strategies measurement largely via outputs, with limited after-action analyses	Outcome measures identified and consistently used for TSMO strategies improvements	Mission-related outputs/outcomes data routinely utilized for management, reported internally and externally, archived
Organization, Staffing, and Culture *(Organizational structure, workforce development, leadership, outreach)*	Fragmented roles based on legacy organization and available skills	Relationship among roles and units rationalized and core staff capacities identified	Top level management position and core staff for TSMO established in central office and districts	Professionalization and certification of operations core capacity positions including performance incentives
Collaboration *(Partnerships among levels of government, public agencies, private sector)*	Relationships on informal, infrequent and personal basis	Regular collaboration at regional level	Collaborative interagency adjust of roles/responsibilities by formal interagency agreements	High level of operations coordination institutionalized among key players (public and private)

3.2. Crash Analysis

As described in Subsection 4.2.1, QWS is a CAV application of particular interest to this study. A QWS detects traffic conditions, identifies if a queue forms, and provides advance warning to the driver of the identified queue. Each of these components varies in design and largely depends on the issue being addressed; common applications include at areas with recurring congestion, high incident rates, facilities with sight distance restrictions, and large-scale work zones. Traditional QWSs rely on fixed traffic sensors to detect queues—and may include video-based detection, microwave sensor, and speed sensor technology, among others. Alerts are typically provided at a fixed location via dynamic message signs, flashing lights, or other warning signs. Figure 6 shows examples of typical QWSs. More advanced QWSs can include variable speeds and individual lane control signals. Likewise, QWSs may be used in conjunction with a speed harmonization program.

Figure 6. Examples of typical queue warning systems (QWSs) ***(34, 35)*****.**

The goal of a QWS is to reduce rear-end crashes and crash severity by alerting drivers of congested and dynamic conditions. QWSs are shown to reduce rear-end crashes by 14% to 44% *(36-38)*. QWSs may be able to leverage CV data to: (1) make more rapid and accurate detection of a queue, (2) extend coverage along a corridor, and (3) provide more effective warnings as messages can be received via onboard units and at optimal locations. Likewise, vehicle responses to queue warnings may be automated in CAVs.

4. METHODOLOGY

Details on how the stakeholder survey and crash analyses were conducted are discussed in this Section.

4.1. Stakeholder Survey

The following Subsections detail the development and dissemination of the electronic survey, how responses were clustered into representative groups for analysis, and utilization of the CAV CMF to provide recommended actions.

4.1.1. Development of Survey

The survey was designed to be brief, easily understood, and accessible to a wide variety of organizations, including those that are non-technical and unfamiliar with CAV technologies. A six-question survey (with an average completion time of under three minutes) was developed comprising of the questions listed in Table 2. Minor, additional questions were also posed to participants; the full survey is included in Appendix B.

Each topical area listed in Question 3 was accompanied by a short summary of potential, related impacts (see Appendix B for these summaries). Topical areas and their accompanying statements were developed from a variety of references, including Smith et al. *(39)*, Kockelman et al. *(40)*, and Walker *(41)*. Due to limited funding and staff resources, an internet-based survey was pursued over paper- or phone-based methods. The survey was developed and disseminated using the Qualtrics XM Platform™ software due to its availability, ability for wide dissemination, efficient tracking, and ease of exporting data.

Table 2. Main questions asked in the survey.

ID	Survey Statement	Possible Response	ID	Survey Statement	Possible Response
1	Please rate your organization's overall **awareness** of CAV technologies and their potential impacts	Very aware Somewhat aware Neither aware nor unaware Somewhat unaware Very unaware	4	Please rate how likely you believe CAV technologies will provide a **meaningful impact** to your organization's (or your division's) purview	Very likely Somewhat likely Neither likely nor unlikely Somewhat unlikely Very unlikely
2	Please rate your organization's overall **perception** of CAV technologies and their potential impacts	Very positive Somewhat positive Neither positive nor negative Somewhat negative Very negative	5	Is your organization (or division) currently planning or preparing for CAV technologies and their potential impacts?	Yes No
3	Please rank the top three (3) topical areas you believe will be most impacted by CAV technologies (in Louisiana)	Public safety Congestion Personal mobility Land use Pollution and the environment Socio-economic characteristics Economy	6	Please rate **how important** it is for your organization (or division) to plan and prepare for CAV technologies and their potential impacts	Very important Somewhat important Neither important nor unimportant Somewhat unimportant Very unimportant

4.1.2. Dissemination of Survey

In total, the survey was disseminated to 165 local agency, 27 state agency, 6 federal agency, 59 nonprofit, and 16 private industry contacts. These contacts may have included members of the same organization but in different divisions. The survey was individually e-mailed to these contacts using unique links for tracking and reporting. Contacts were asked to complete the survey on behalf of their organization or division within the organization. E-mail addresses were obtained from their organization's public webpage. If an e-mail address was not readily available, the organization was contacted (via a phone call) to obtain the appropriate contact and e-mail address.

Contacts were generally grouped in the following functional categories: advocacy groups (related to socio-economic equity), aging communities, disadvantaged (disabled) groups, economic development, environmental quality, freight, planning, public safety, traffic operations, and transit. These groups are summarized in Table 3. The complete list of contacted organizations is included in Appendix C.

Table 3. Distribution of those contacted to participate in the survey.

Functional Category	Local Agency	State Agency	Federal Agency	Nonprofit	Private Industry	Total
Advocacy Groups (ADV)	0	0	0	12	0	12
Aging Communities (AGE)	67	2	1	0	0	70
Disadvantaged Groups (DAV)	0	5	0	27	0	32
Economic Development (ECN)	16	4	0	3	0	23
Environmental Quality (ENV)	11	4	1	5	0	21
Freight (FRT)	28	2	0	2	9	41
Planning (PLN)	11	2	1	10	0	24
Public Safety (PST)	9	5	1	0	0	15
Traffic Operations (OPS)	10	2	1	0	7	20
Transit (TRT)	13	1	1	0	0	15
	165	27	6	59	16	273

Contacted advocacy groups consisted of local and state nonprofit organizations with a focus on building more equitable communities—most with the aim of solving economic inequity (versus gender or race inequality). Aging communities comprised of organizations providing care and other services to the elderly. Those contacted included each parish (64 in total) council on aging (COA), other area-specific COAs, and the Governor's Office of Elderly Affairs. COAs provide critical transportation services to the elderly in Louisiana.

Contacted disadvantaged groups mainly comprised of local Arc associations—who provide services to those with intellectual and developmental disabilities. Together with transit systems and COAs, Arc associations provide a critical public transportation service in Louisiana. City chambers of commerce, regional economic alliances, and regional planning commissions were contacted as part of the economic development category. City environmental services, environmental quality regional offices, and other state government environmental agencies were also contacted.

The freight category involved each airport in Louisiana providing commercial services (7), each port (22), and the ten largest trucking companies operating in Louisiana, among others. Contacted planning agencies comprised of city planning commissions, regional planning commissions, and several nonprofits aimed at improving planning practices in Louisiana. Contacted safety organizations included each established regional safety coalition and several safety-related programs within LaDOTD. Traffic operation groups comprised of city traffic engineering departments, MPOs, and several ITS-related consultants working in Louisiana. Lastly, each transit provider (13) in Louisiana was also contacted.

4.1.3. Clustering of Responses

For deeper analysis, responses were coded as numerical values and assumed to have a cardinal relationship (versus ordinal ranking) with one unit of separation between each possible consecutive response. Participants were partitioned into like groups using a simple k-means clustering algorithm with squared Euclidian distance as the distance function and random partition as the initialization method. Responses from Questions 1, 2, 4, and 6 were used as inputted data points. Clusters of size k = 2, 3, 4, and 5 were analyzed. Each k cluster was initiated using 15 different random seeds, and the optimal cluster group (minimizing within-cluster variances) among these runs was selected. In order to determine the ideal number of clusters, the Davies-Bouldin index was calculated for each optimal k cluster. There was minimal variation of the Davies-Bouldin index across cluster sizes; ultimately, cluster k = 3 was selected for analysis due to its easy interpretation and suitability in developing the list of recommended actions. The cluster analysis was conducted using the open-source software WEKA© due to its many available clustering algorithms and options, ease of use, and detailed documentation.

4.1.4. CAV Capability Maturity Framework

Recognizing distinct characteristics of vehicle-to-infrastructure (V2I) applications, Gettman et al. *(42)* modified the TSMO CMM to develop a CAV-specific CMF. The CAV CMF includes a series of comprehensive activity tables that specify for each dimension and maturity level the attributes listed in Table 4. This information is meant to provide guidance to agencies conducting a self-evaluation.

Table 4. Attributes defined in the CAV CMF for each dimension and maturity level to assist agencies in self-evaluation *(42)*.

Attribute	Definition
Relevance	How V2I introduces specific challenges and requirements
State of play	Current status of the agency's capability level
Objective	Goal of actions to improve capability maturity in this dimension
General strategy	Broad description of the strategies involved in advancing capability to the next level
Relationship to TSMO	Degree to which V2I applications relate to existing TSMO applications in this dimension
Caveats	Special consideration and dependencies that are specific to this dimension
Actions to next level	Enabling activities to improve V2I capability in this dimension
Synergies	Other dimensions in the CAV CMF that are closely related to this dimension
Key stakeholders	Agencies and groups that are important to include in decision making surrounding planning and actions for the dimensions
Questions to consider	Questions for an agency to ask itself in its self-assessment and determination of maturity levels for the dimension

Since the survey investigated the views of external agencies and not internal LaDOTD operations, this study exclusively focuses on the collaboration dimension of the CAV CMF. An assessment of the maturity level of this dimension was conducted using the corresponding activity tables (see

Table 4). The recommend actions in Subsection 6.1 were mainly developed from the "actions to next level" and "questions to consider" attributes—as well as best practices of more mature state DOT CAV programs (from Lopez et al. *(24)*, Iowa DOT *(23)*, and Walz *(43)* predominately). We refer the reader to Gettman et al. *(42)* as details are too exhaustive to duplicate here.

4.2. Crash Analysis

As stated in Subsection 3.1.1, LaDOTD's CAV Action Plan contains four deployments of QWSs across the State: one in East Baton Rouge, Jefferson, St. Tammany, and West Baton Rouge parishes. Due to the prevalence of this CAV application in the Plan, it was selected for further analysis—to determine if the proposed deployment scenarios are suitable candidates for QWS. The Plan defines the key performance indicators of a QWS as: (1) number of rear-end crashes, (2) crash severity, (3) incident detection time, and (4) incident response time. Utilizing historical crash data, this study will conduct a crash analysis at each proposed location—and focusing on (1) and (2) metrics, provide recommendations on the suitability of QWS deployment.

The following Subsections detail the process and method, data, and spatial limits of the conducted crash analyses.

4.2.1. Process and Method

The crash analysis was conducted strictly following LaDOTD guidelines *(44, 45)*—which are summarized in the following steps:

> Step 1: Divide area of interest in homogenous segments based on functional classification, annual average daily traffic (AADT), and geometric features.
>
> Step 2: Using historical crash data, calculate the crash rate for each segment with the number-rate method (Equation 1).
>
> Step 3: Compare crash rate with the statewide average crash rate for the corresponding roadway classification. Determine any "abnormal" locations.
>
> Step 4: Calculate the severity distribution for total crashes. Compare with statewide average severity distribution by roadway classification.
>
> Step 5: Calculate the distribution of collision type for all crashes. Identify crash types which may be "overrepresented" (compared to the corresponding statewide average).
>
> Step 6: Utilizing developed safety performance functions (SPF), calculate predicted crashes per mile per year (Equation 3) for all crashes and F&SI (fatal and serious injury) crashes.
>
> Step 7: Compare the above to statewide averages, and determine the Level of Service of Safety (LOSS) (Table 6).

Step 1: Identified corridors were divided into homogenous segments using the "LaDOTD Surface-Type Log File" tool. The tool lists homogenous segments of state-owned roadways organized by parish, route, and control section log-mile. Length, AADT, number of lanes, pavement type/width, shoulder width, and median type/width is provided for each segment.

Step 2: The crash rate for each segment was calculated using Equation 1:

$$R_{seg} = \frac{C*10^6}{T*VMT} \quad [1]$$

where:
R_{seg} = segment crash rate (crashes per M veh-mi);
C = total number of crashes;
T = number of analysis years;
VMT = vehicle miles traveled (veh-mi per year)

VMT is calculated using Equation 2:

$$VMT = L * AADT * 365 \quad [2]$$

where:
L = length of segment (mi); and
$AADT$ = annual average daily traffic (veh per day).

Step 3: The statewide average crash rate for each highway classification is provided by LaDOTD *(44)* and calculated on a three-year running average. Highway classifications used in this analysis varied by location, but primarily included: rural four-lane interstate, urban four-lane interstate, and urban six-lane interstate. "Abnormal" locations are defined as those having a crash rate two-times or higher than the average statewide crash rate (and with at least five crashes). Steps 1–3 provide a general "rule-of-thumb" and are used to identify segments which may be a "good" candidate for safety improvements.

Step 4: The statewide average severity distribution by roadway classification is also provided by LaDOTD *(44)*. Fatal and severe severity levels (respectively) were compared, as crash severity is a metric of interest.

Step 5: LaDOTD *(44)* also provides statewide average distributions by collision types. Distribution of rear-end crashes were compared.

Step 6: Predicted crashes per year (PCY) were calculated from LaDOTD-defined SPFs *(45)*. The SPF used in this study is defined in Equation 3. The coefficients varied by roadway classification and are listed in Table 6.

$$PCY = \beta_0 * L^{\ 1} * AADT^{\ 2} * e^{\ 3*AADT} \quad [3]$$

where:
$\beta_0, \beta_1, \beta_2, \beta_3$ = SPF coefficients.

Table 5. Values of safety performance function (SPF) coefficients used in the study *(45)*.

Roadway Classification	β_0	β_1	β_2	β_3	b
For All Crashes					
Rural four-lane divided	0.0022	0.7350	0.7314	2.18×10^{-5}	2.9468
Urban four-lane divided	2.38×10^{-5}	0.6276	1.3364	2.24×10^{-6}	2.7348
Urban six-lane	0.1138	0.9508	0.5162	1.81×10^{-5}	6.2046
For F&SI Crashes					
Rural four-lane divided	1.45×10^{-5}	0.8425	1.2063	-2.31×10^{-5}	1.4528
Urban four-lane divided	3.03×10^{-5}	0.7409	1.1855	-1.33×10^{-5}	2.7932
Urban six-lane	0.0127	1.1710	0.6075	0	3.8905

Step 7: For all crashes, the corrected (correction for the regression to the mean bias) crashes per mile per year, $CMY(EB)$, is calculated using the following equations:

$$CMY(EB) = \frac{WA*PCY \quad (1-WA)*CY}{L^{\beta_1}} \qquad [4]$$

where:
WA = weighted adjustment; and
CY = observed crashes per year.

CY is calculated as in Equation 5:

$$CY = \frac{Number\ of\ Crashes}{Number\ of\ Years} \qquad [5]$$

WA is calculated using Equation 6:

$$WA = \frac{1}{1+PC \quad *OP} \qquad [6]$$

where:
OP = over-dispersion parameter.

And finally, OP is calculated using Equation 7:

$$WA = \frac{1}{b*L^{\beta_1}} \qquad [7]$$

$CMY(EB)$ is then compared to the statewide average predicted crashes per mile per year (SWA). SWA is calculated as in Equation 8. LOSS is determined using the inverse-gamma cumulative distribution function (Equation 9) and percentile thresholds in Table 6.

$$SWA = \frac{PCY}{L^{\beta_1}} \qquad [8]$$

$$F(x;\alpha,\beta) = \frac{\Gamma(\alpha, \quad)}{\Gamma(\alpha)} \qquad [9]$$

where:
x = probability;
α = shape parameter;
β = scale parameter; and
$\Gamma(*)$ = gamma function.

For our purposes, α is taken as the coefficient b. β is PCY divided by b.

Table 6. Definition of the Level of Service of Safety (LOSS) classifications *(45)*.

LOSS	Definition	Criteria
LOSS 1	Low potential for safety improvement	$CMY(EB) \leq F(0.2, \alpha, \beta)$
LOSS 2	Low to moderate potential for safety improvement	$F(0.2, \alpha, \beta) < CMY(EB) \leq F(0.5, \alpha, \beta)$
LOSS 3	Moderate to high potential for safety improvement	$F(0.5, \alpha, \beta) < CMY(EB) \leq F(0.8, \alpha, \beta)$
LOSS 4	High potential for safety improvement	$CMY(EB) > F(0.8, \alpha, \beta)$

The LOSS is a general, guiding measure used to determine if a location is a "good" candidate for safety improvements. To calculate the LOSS for F&SI, the process is the same as outlined in Steps 6 and 7—except the SPF for F&SI is used instead of the SPF for all crashes (see Table 5).

4.2.2. Historical Crash Data

The analyses outlined in Subsection 4.2.1 require a minimum of three years of historical crash data *(44)*. Five years of crash data is recommended if no significant changes occurred at the location (or surrounding location) within that timeframe. This study used the latest available five year crash data: from January 1, 2015 to December 31, 2019. Crash data was obtained from the "LaDOTD Highway Crash List" database. The database is access-controlled; the research team obtained permission from LaDOTD to use the database and followed the necessary procedures to gain access.

For each analyzed location, a complete list of all crashes were generated following procedures outlined in the "LaDOTD Highway Crash List" manual *(46)*. Obtained data elements of interest included: location (milepost), date and time, manner of collision, severity level, surface condition, if crash involved alcohol, if a roadway departure crash, lighting condition, and roadway classification. From the generated crash list, crashes were organized and compiled into homogenous segments (and analyzed according to Subsection 4.2.1).

4.2.3. Analyzed Locations

Based on general descriptions of the four possible QWS deployments in the CAV Action Plan, the research team defined limits for each analysis location. This included:

1. A 4.470-mi segment of I-110 near the Governor's Mansion in East Baton Rouge Parish, specifically from 0.000 mile point to 4.4710 mile point. See Figure 7.
2. A 9.349-mi segment of I-10 near Louis Armstrong New Orleans International Airport in Jefferson Parish, from 221.709 mile point to 229.309 mile point. See Figure 8.
3. A 12.517-mi segment of I-10 in West Baton Rouge Parish, from 141.901 mile point to 154.418 mile point. See Figure 9.
4. A 15.341-mi segment of I-12 in St. Tammany Parish, from 71.312 mile point to 86.653 mile point. See Figure 10.

4.3. AMS CAV Case Study

As described in Section 2, the original intention of this study was to conduct AMS CAV case studies utilizing existing modeling networks. The research team solicited microsimulation modeling networks through "SimCap Louisiana" *(47)*. "SimCap Louisiana" is a volunteer network of professionals that support, promote, and improve best practices in the application of traffic simulation and capacity analysis—and is a Chapter of the ITE SimCap Committee *(48)*. Several modeling networks (developed from prior consulting projects) were received and reviewed. Those reviewed were not suitable for the envisioned analysis—mainly due to limited geographic coverage (e.g., focused on a single interchange with limited segments upstream and downstream of that interchange). More importantly, after discussions with corresponding LaDOTD staff, it was not recommended to apply these models outside of their original purpose. Therefore, the research team shifted their focus to related CAV analyses that would be viewed by LaDOTD (and similar local and state DOTs) as valid, insightful, and that support implementation.

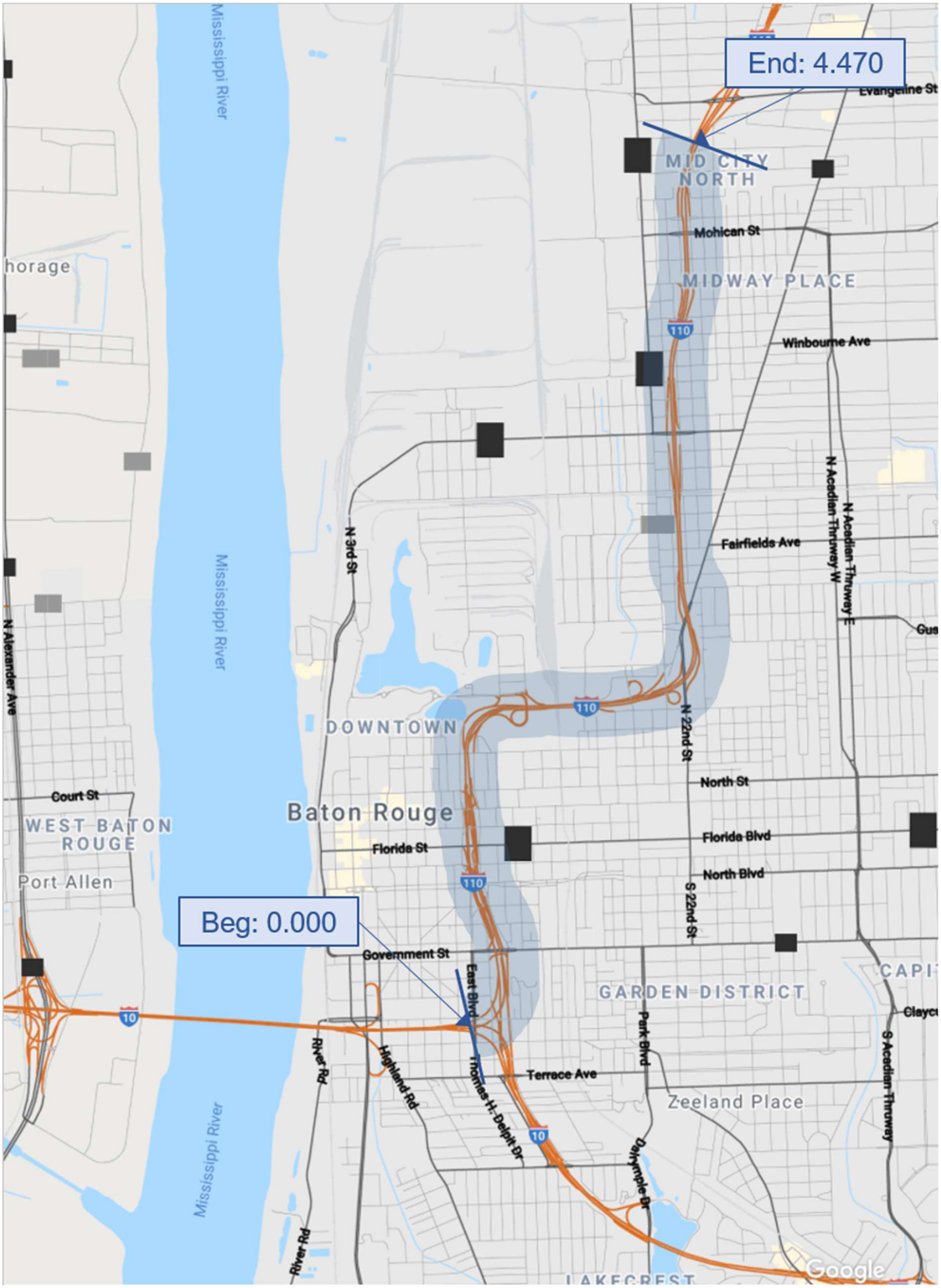


Figure 7. Study location along I-110 in East Baton Rouge Parish.

Figure 8. Study location along I-10 in Jefferson Parish.

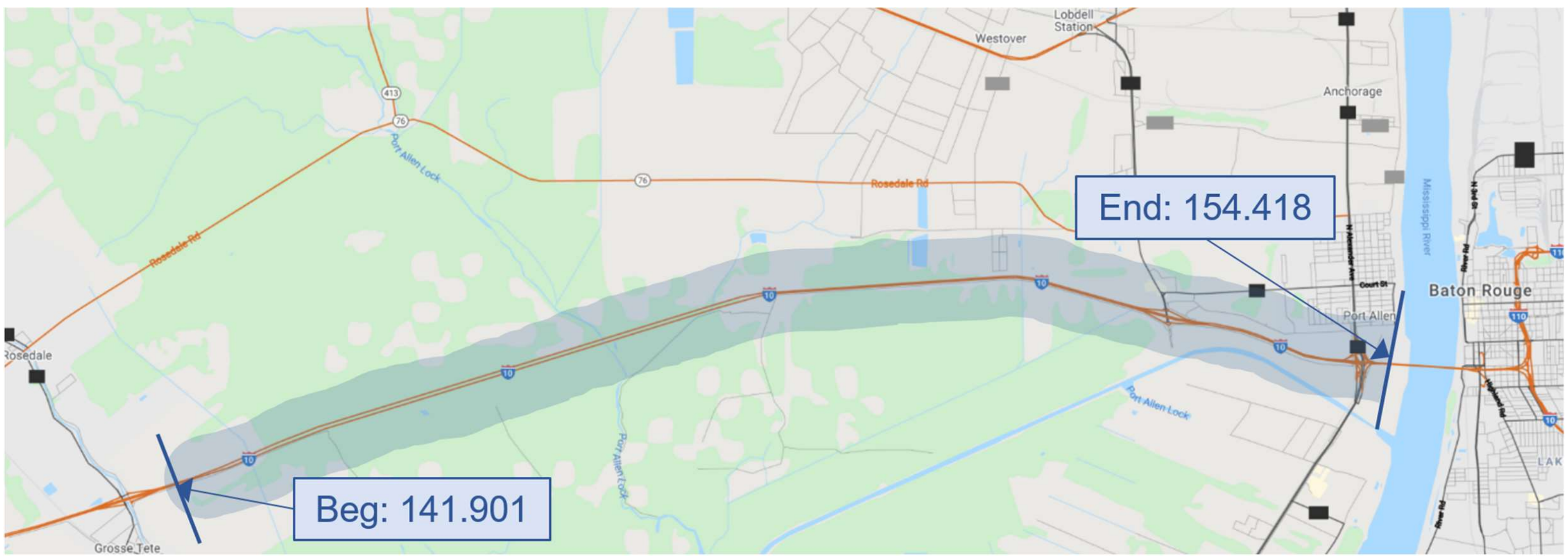


Figure 9. Study location along I-10 in West Baton Rouge Parish.

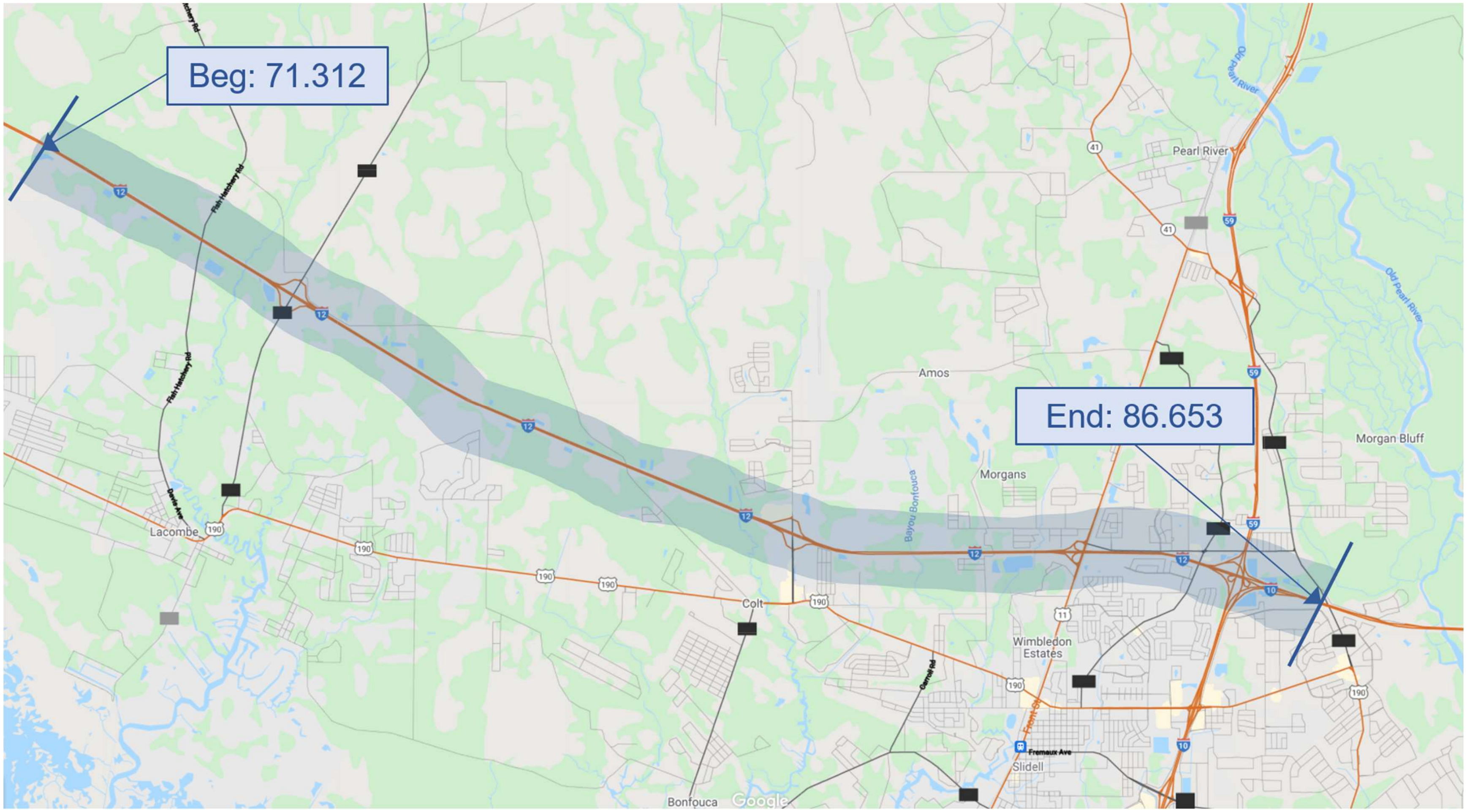


Figure 10. Study location along I-12 in St. Tammany Parish.

5. ANALYSIS AND FINDINGS

This Section presents results of the stakeholder survey and conducted crash analysis.

5.1. Stakeholder Survey

In total, 117 participants completed the survey, including representatives from 57 local agencies, 19 state agencies, 5 federal agencies, 24 nonprofits, and 12 private companies. Breakdown of the completion rate of those contacted (from highest to lowest) by functional category is as follows: traffic operations (85%), public safety (80%), transit (60%), advocacy groups (58%), planning (58%), economic development (39%), aging communities (33%), freight (32%), disadvantaged groups (25%), and environmental quality (24%). Due to low completion rates, participants of the latter two organizations may not be representative.

Survey responses were clustered in three main groups, which can generally be summarized as: Group A—those uninformed of CAV technologies and do not believe their organization will be significantly impacted, Group B—those more informed of CAV technologies but still do not believe their organization will be impacted, and Group C—those well informed, perceive CAV technologies positively, believe their organization's purview will be impacted, and that it is important to prepare. Figure 11 shows the composition of each group by functional category. Stated percentages represent the portion of participants from the respective category within that group, and a bolded border indicates the group each category primarily resides within.

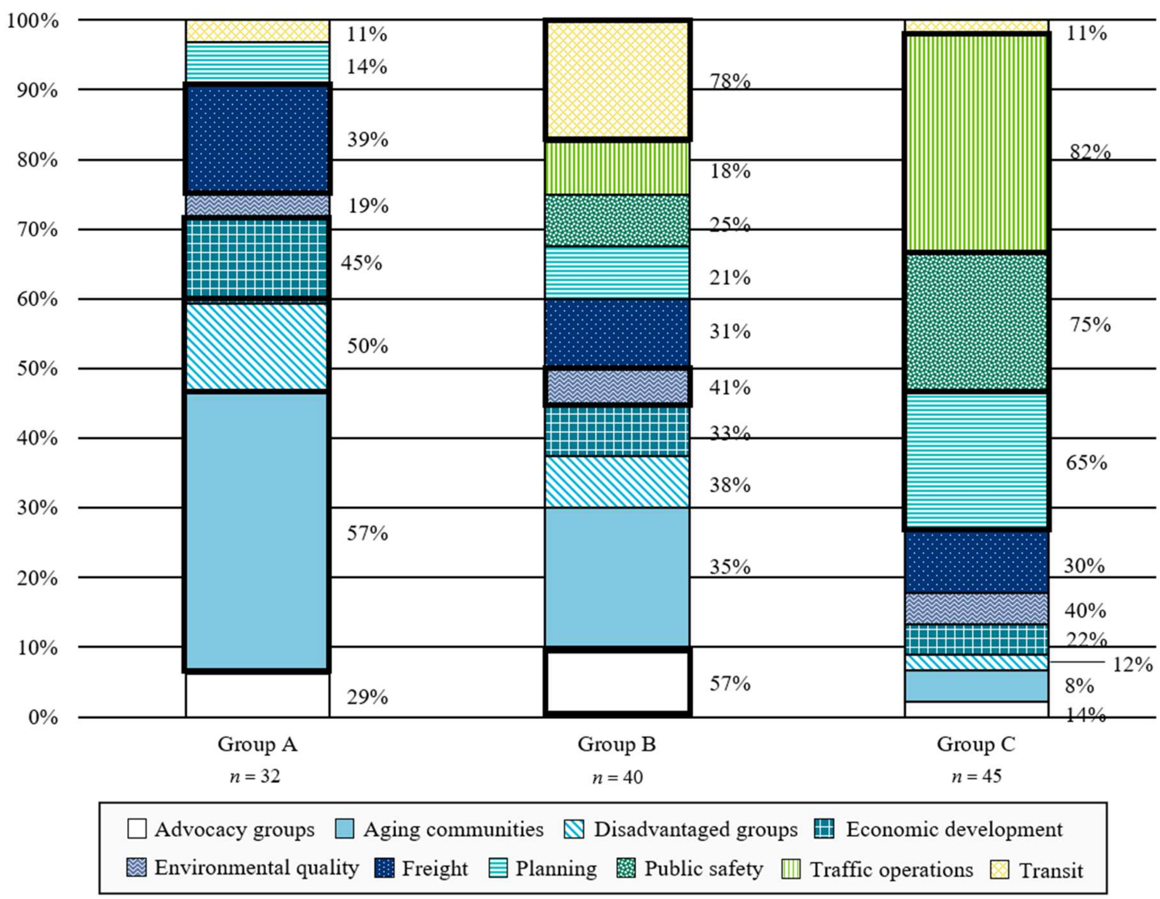


Figure 11. Composition of survey responses in three main groups (clusters) by functional category.

As shown in Figure 11, the majority of participants from aging communities, disadvantaged groups, economic development, and freight are in Group A. The majority of participants from advocacy groups, environmental quality, and transit are in Group B, and the (significantly large) majority of participants from planning, public safety, and traffic operations are in Group C. Figure 12 denotes the average response by functional category to Questions 1 ("Awareness"), 2 ("Perception"), 4 ("Likelihood of Impact), and 6 ("Importance of Preparation"). The error bars represent the 95% confidence interval on the population mean assuming a normal distribution $\bar{x} - t_{\frac{\alpha}{2},n-1}\frac{s}{\sqrt{n}} \leq \mu \leq \bar{x} + t_{\frac{\alpha}{2},n-1}\frac{s}{\sqrt{n}}$. Vertical lines represent the average response by group.

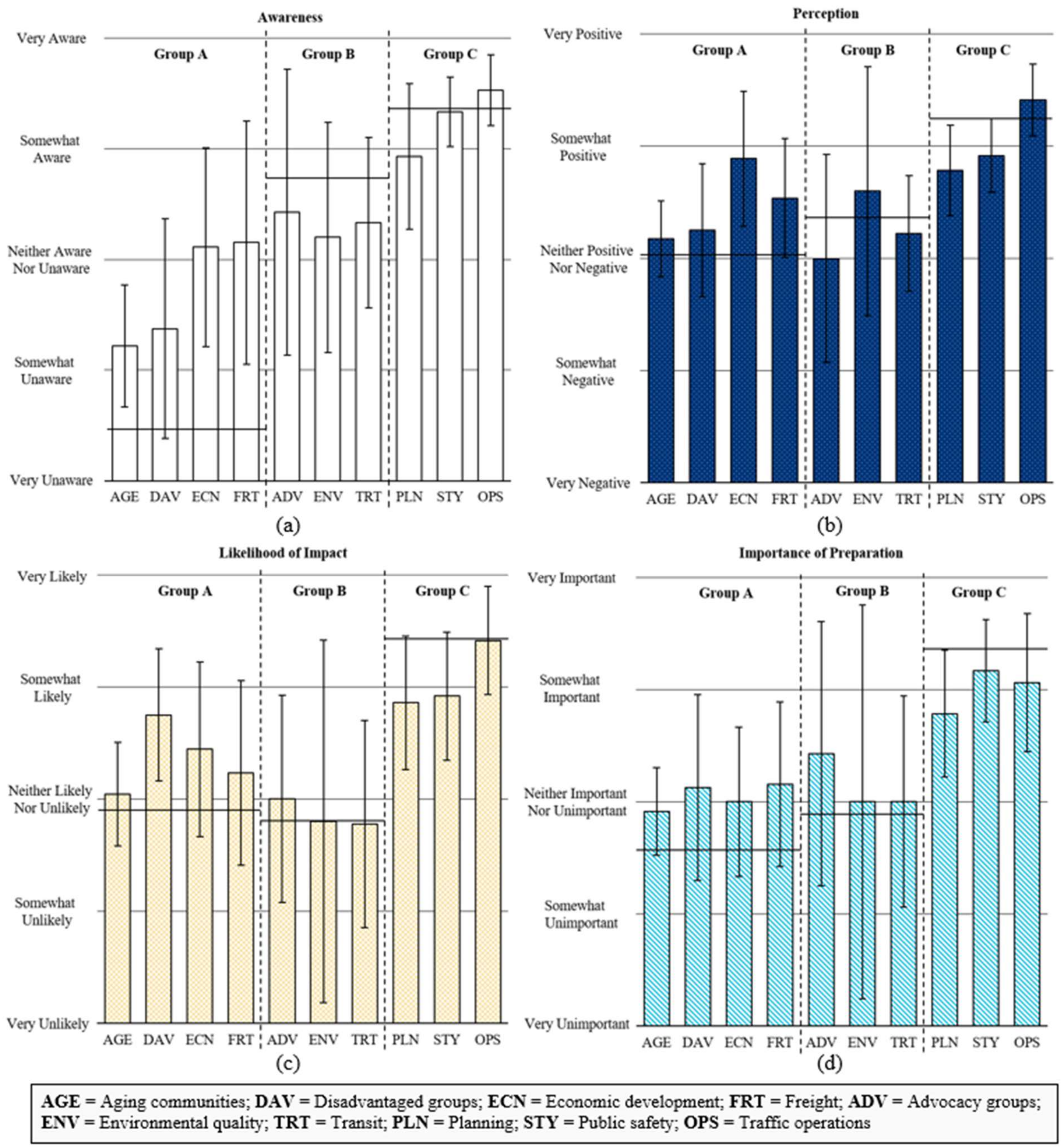


Figure 12. Average participant response by functional category and group to questions related to: (a) awareness, (b) perception of CAV technologies, (c) likelihood of them impacting organizational purview, and (d) importance of planning.

The relationship between awareness and perception was statistically tested through a linear regression analysis utilizing all individual responses and a corresponding hypothesis test ($\alpha = 0.05$, $R^2 = 0.250$, $\rho = 3.00 \times 10^{-7}$). The test showed a statistically significant relationship. This indicates that educational initiatives may improve the perception of CAV technologies to these organizations. This aligns with past studies which have shown that individuals have more positive attitudes towards CAV technologies when more properly informed and aware *(49)*. Generally, the levels of awareness by each organizational category is as expected (e.g., low awareness of CAV technologies by aging communities and disadvantaged groups, high awareness by public safety and traffic operations officials). However, key exceptions include the low awareness and perception by economic development, freight, and transit groups. This is further compounded by the low levels of perceived impact and importance of CAV planning by freight and transit operators. Freight and the efficient movement of freight is a critical component to the Louisiana economy; Louisiana contains one of the largest freight distribution hubs (New Orleans, LA) and most valuable truck corridors in the U.S. (Interstate 10) *(50)*. The large gap between the perceived high likelihood of impact and low importance of planning by economic development groups may also indicate an area of concern.

Figure 13 shows the relationship between survey Questions 5 ("Percent Preparing") and 6 ("Importance of Preparation") by organization type. Error bars represent the average normalized by functional category, such that results are not skewed by an overrepresentation of agencies from a particular functional category within each organization type. Figure 13 also lists the number of responses per category type (n) and as a percentage of those contacted to participate. As shown, despite the relatively consistent response between these organizations ("Somewhat Important" for their organization to prepare for CAV technologies), there is wide variability in which organizations are preparing currently; while all surveyed federal agencies are preparing (in some form), only a small portion of local and state agencies, and especially nonprofits, are preparing.

Those respondents who answered "Very Likely" or "Somewhat Likely" to Question 4, were also asked to estimate the most likely timeframe in which impacts would occur: either in the long-term (beyond 10 years from now), mid-term (4 to 10 years from now), or short-term (0 to 4 years from now). 65 participants answered this question. Figure 14 shows their distribution.

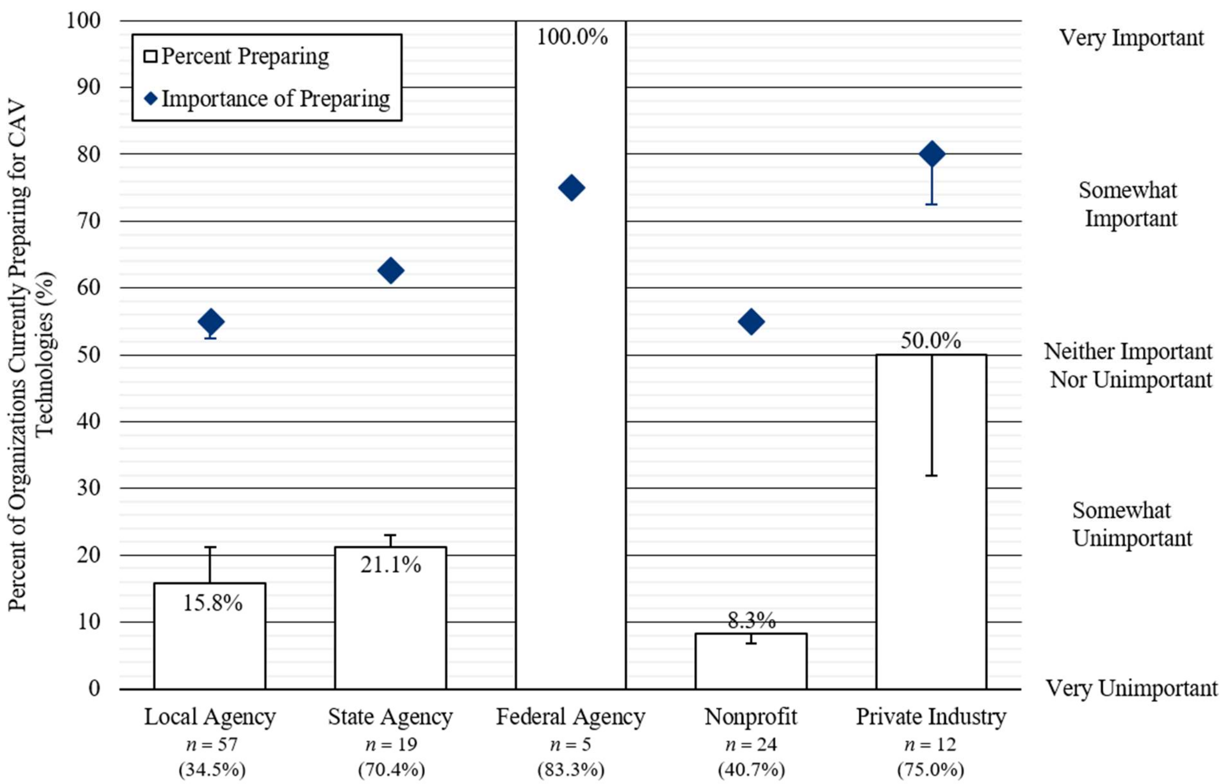


Figure 13. Percentage of respondents currently preparing for CAV technologies (left axis) and average response to the importance of CAV planning (right axis) by organization type.

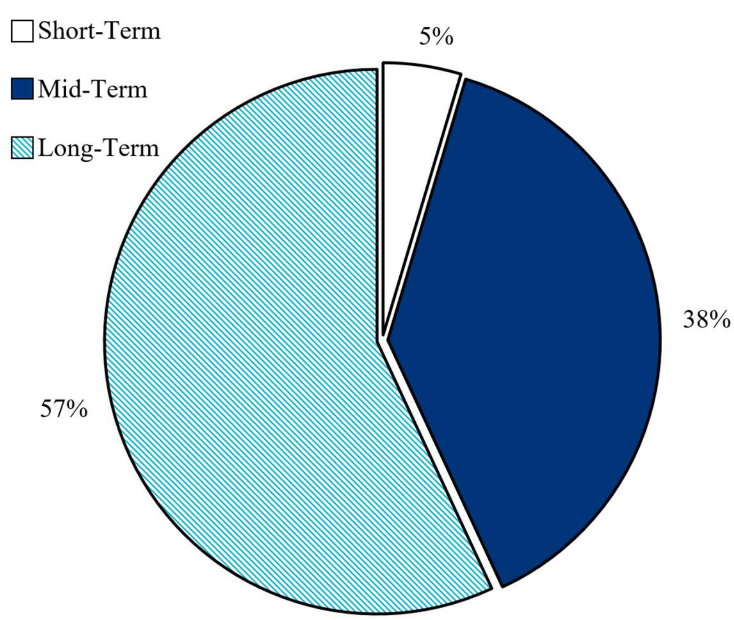


Figure 14. Distribution of the timeframe in which CAV-related impacts would occur as estimated by survey participants.

Another purpose of the survey was to identify the topical area viewed to be the most impacted by CAV technologies in Louisiana (see Question 3 in Table 2). Figure 15 shows the percentage of respondents who selected each topical area as their top three areas to be most impacted. Responses were normalized by functional category. As shown, personal mobility (18.8%) and economy (17.9%) were selected as the top fields, followed by public safety (17.5%) and congestion (16.0%). Overall, organizations tended to select their organizational purview as being the most impacted (e.g., most of aging communities elected personal mobility, economic development groups selected economy, advocacy groups selected socio-economic characteristics, etc.).

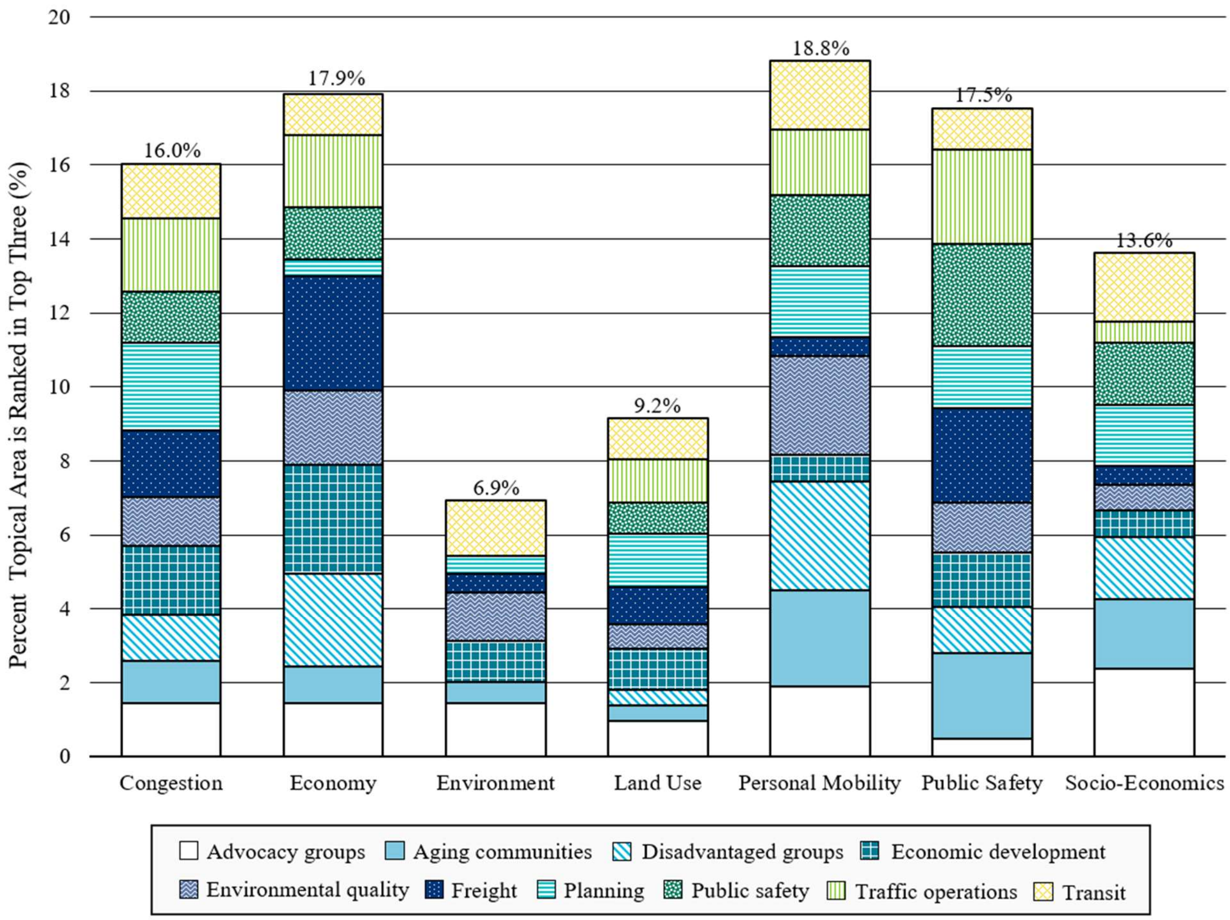


Figure 15. Percent each topical area was selected by respondents as the area to be most impacted by CAV technologies organized by functional category.

5.2. Crash Analysis

Findings presented in this Subsection are subject to provisions of 23 U.S.C. 409 *(51)*. Any intentional or inadvertent release of this material, or any data derived from its use, does not constitute a waiver of privilege pursuant to 23 U.S.C. 409, which reads as follows:

> *Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or*

admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

Likewise, it was recommend to admit specific values of the number of crashes, calculated crash rates, severity distributions, and other safety metrics. Therefore, the following Subsections present and discuss only the key findings from the crash analysis. Findings are summarized by: crash rate, severity level, manner of collision, and LOSS (for all crashes and F&SI crashes). It is important to reiterate that the following content, interpretations, and views are solely the authors.

5.2.1. The East Baton Rouge Parish Location

Table 7 summarizes key findings from the crash analysis for the East Baton Rouge Parish location. The studied corridor was divided into seven homogenous segments. As shown in Table 7, the high number of segments identified as "abnormal", including one identified as LOSS 4, may warrant a safety improvement. However, rear-end crashes are not overrepresented. On the other hand, side-swipe crashes are overrepresented. Despite having known, significant recurring congestion along the corridor, and by nature of the highway classification (urban six-lane interstate) having predominantly rear-end crashes, this location may not be the most suitable for a QWS. Significant weaving movements along the corridor and recurring backup on several entrance/exit ramps may also be contributing factors. Although a QWS may be helpful, pursuing other, additional safety improvements may be recommended.

Table 7. Key findings from the crash analysis for the East Baton Rouge Parish location.

Metric	Key Findings
Crash rate	• Three of seven segments identified as "abnormal" locations[1]; and • All segment crash rates above the corresponding statewide average (1.70 crashes per M veh-mi).
Severity level	• Three of seven segments well above the corresponding statewide average distribution for fatal crashes (0.33%).
Manner of collision	• Six of seven segments below the corresponding statewide average distribution for rear-end crashes (51.35%); • Six of seven segments above the corresponding statewide average distribution for side-swipe crashes (22.52%), two segments well above the average; and • Two of seven segments well above the corresponding statewide average distribution for head-on collisions (0.55%).
Level of service of safety: All crashes	• Six of seven segments were identified as LOSS 1; and • One segment was identified as LOSS 4.
Level of service of safety: F&SI crashes	• Four of seven segments were identified as LOSS 1; and • Three of seven segments were identified as LOSS 2.

[1]Defined as having a crash rate two-times or higher than the corresponding statewide average

5.2.2. The Jefferson Parish Location

The studied section of I-10 in Jefferson Parish was divided into eight homogenous segments. Key findings from the crash analysis are listed in Table 8. As shown, the corridor includes one "abnormal" location and two locations with overrepresented severe crashes. Of particular importance: there is a clear overrepresentation of rear-end crashes along the entire corridor. The severity distribution also reflects those of rear-end crashes (non-fatal, predominantly property damage only, with some being severe). This supports recommending the location for a QWS.

Table 8. Key findings from the crash analysis for the Jefferson Parish location.

Metric	Key Findings
Crash rate	• One segment identified as an "abnormal" location[1]; and • Six of eight segment crash rates above the corresponding statewide average (1.70 crashes per M veh-mi).
Severity level	• All segments below the corresponding statewide average distribution for fatal crashes (0.33%); and • Two of eight segments above the statewide average distribution for severe crashes (0.84%).
Manner of collision	• All segments above the corresponding statewide average distribution for rear-end crashes (51.35%), four segments well above the average; and • Four of eight segments above the corresponding statewide average distribution for side-swipe crashes (22.52%).
Level of service of safety: All crashes	• All segments were identified as LOSS 1.
Level of service of safety: F&SI crashes	• Seven of eight segments identified as LOSS 1; and • One segment was identified as LOSS 3.

[1]Defined as having a crash rate two-times or higher than the corresponding statewide average

5.2.3. The West Baton Rouge Parish Location

Key findings from the crash analysis for the West Baton Rouge Parish location are presented in Table 9. A safety improvement may be warranted based on the high number of "abnormal" locations, overrepresented fatal crashes, and overrepresented severe crashes. Rear-end crashes are overrepresented on all segments (including the highest distribution of rear-end crashes of all four locations). A QWS would be most suitable in this location—and may be able to reduce the number of rear-end crashes and crash severity.

Table 9. Key findings from the crash analysis for the West Baton Rouge Parish location.

Metric	Key Findings
Crash rate	• Four of eight segments were identified as "abnormal" locations[1]; and • All segment crash rates above the corresponding statewide average (1.00 crashes per M veh-mi).
Severity level	• Three of eight segments above the corresponding statewide average distribution for fatal crashes (0.68%), one segment well above; and • Two of eight segments above the statewide average distribution for severe crashes (0.72%).
Manner of collision	• All segments above the corresponding statewide average distribution for rear-end crashes (44.63%), all segments well above; and • Six of eight segments above the corresponding statewide average distribution for side-swipe crashes (20.27%), one segment well above.
Level of service of safety: All crashes	• Six of eight segments were identified as LOSS 1; and • Two segments identified as LOSS 2.
Level of service of safety: F&SI crashes	• Four of eight segments identified as LOSS 1; • Three segments identified as LOSS 2; and • One segment was identified as LOSS 3.

[1]Defined as having a crash rate two-times or higher than the corresponding statewide average

5.2.4. The St. Tammany Parish Location

Table 10 summarizes findings from the crash analysis for the St. Tammany Parish location. As shown, all segment crash rates were below the statewide average for the corresponding highway classification (urban four-lane interstate). Likewise, segments are considered to have low potential for safety improvement. Overall, distribution of rear-end crashes were well below the corresponding statewide average. However, non-collision crashes and roadway departure crashes are overrepresented. Non-collision crashes involve a single vehicle striking an off-road object or involve a rollover *(52)*. This location may not be suitable for a QWS; perhaps, safety improvements aimed at roadway departure should be investigated.

Table 10. Key findings from the crash analysis for the St. Tammany Parish location.

Metric	Key Findings
Crash rate	• No segments identified as "abnormal"; and • All segment crash rates below the corresponding statewide average (1.00 crashes per M veh-mi).
Severity level	• Two of seven segments well above the corresponding statewide average distribution for fatal crashes (0.68%), and • Two of seven segments well above the statewide average distribution for severe crashes (0.72%), both well above.
Manner of collision	• Six of seven segments below the corresponding statewide average distribution for rear-end crashes (51.35%); • All segments below the corresponding statewide average distribution for side-swipe crashes (20.27%); • All segments well above the corresponding statewide average distribution for non-collision crashes (27.57%); and • All segments above the corresponding statewide average distribution for roadway departure crashes (29.94%), two well above.
Level of service of safety: All crashes	• All segments identified as LOSS 1.
Level of service of safety: F&SI crashes	• All segments identified as LOSS 1.

[1]Defined as having a crash rate two-times or higher than the corresponding statewide average

6. CONCLUSIONS

This Section lists and discusses possible recommended actions to advance strategic partnerships, extensions of the crash analyses, and recommendations to conduct AMS case studies to support the "CAV Technology Team" (or similar entity at other local and state DOTs).

6.1. Recommended Actions from Stakeholder Survey

A basic assessment of LaDOTD related to the collaboration dimension of the CAV CMF was conducted by the authors. Primarily because external stakeholders are not currently involved in CAV-related preparatory actions, the assessment resulted in a capability level of 1 (see "state of play" in Table 4). The following recommendations are meant as near-term actions to be taken by LaDOTD (or similar state DOTs, see Subsection 3.1.2) to move towards a capability level of 2 (and beyond). Recommendations are generalized in the hope of providing benefit to other transportation agencies.

6.1.1. Establish External CAV Advisory Council and Forum for Sustained Stakeholder Engagement

Although most organizations surveyed (those in Groups A and B) may not believe it is important to prepare for CAV technologies, they are still interested in better accomplishing their respective missions and maximizing benefits to their constituents. For example, 60% of survey respondents were interested in keeping abreast of this study. This high interest may indicate their willingness to participate, contribute to, and be leveraged in future CAV-related initiatives. Likewise, as stated in Subsection 3.1.1, external agencies have had limited involvement in CAV activities conducted by LaDOTD. Establishing an advisory council comprised of diverse public and private agencies (those surveyed)—and conducting regular forums to continually engage and receive feedback from these agencies—will act as the basis for fostering and sustaining strategic partnerships. The forum may include updates on current LaDOTD activities and encourage feedback—reinforcing that external advice is welcomed, valuable, and utilized in shaping emerging programs. It can be used to identify potential "champions" and key partners, the beginning of identifying their roles and responsibilities in deployment, a mechanism to collaborate, discuss, and obtain consensus on potential CAV applications, and the first step in developing a regional consensus framework for CAV policy and planning.

6.1.2. Create Targeted Stakeholder Outreach Plans with Customized Education Component

As shown in Subsection 5.1, awareness of CAV technologies varied greatly from organization to organization: low awareness in Group A to high awareness in Group C. Therefore, it is recommended to develop stakeholder outreach plans with an educational component customized to each clustered group. Likewise, since some likely partners had low awareness (transit, freight, and economic development agencies), it will be imperative to educate these agencies on CAV technologies, their benefits and risks, timelines for development, and how implementation may help serve their aspirations. These information campaigns may be tied to the above forum, an extension of educational workshops/meetings associated with the LaDOTD "CAV Technology Team", or consist of promoting existing resource material (e.g., by NACo *(53)*, NGA *(54)*, Hallmark et al. *(55),* etc.). Another existing resource could include the recent effort by the Louisiana Local Technical Assistance Program (LTAP)—which developed a list of curated resources to assist local agencies in preparing for CAV technology *(56)*. The collection is not meant to be exhaustive, but to provide key resources to initially inform and assist local agencies in their own preparatory efforts. The list is located on their website and categorized as to: (1) gain knowledge of the technology and infrastructure requirements, (2) assess potential of CAV deployment, and (3) identify and pursue preparatory actions. The main CAV-related efforts in Louisiana (see Subsection 3.1.1) are also listed on their website and will continually be tracked and updated.

Developing a public awareness campaign is also recommended to address common concerns or misconceptions regarding the technology, communicate program and project updates, and foster general support. Once partnering agencies are sufficiently informed and educated, it may be possible to leverage their public outreach capabilities and processes; several organizations (e.g., MPOs, advocacy groups, and disadvantaged groups) may be better suited for such public awareness initiatives. One successful example of this is the extensive stakeholder outreach conducted by Minnesota DOT's CAV Advisory Council: hosting 26 public events between July – October 2018, each focusing on one of 10 subcommittee areas and targeting nontraditional transportation stakeholders *(43)*. Meetings provided an overview of the subcommittee, CAV technology, and potential transportation system impacts. The majority of participants found the presented information helpful and were willing to attend future events.

6.1.3. Conduct KSA (Knowledge, Skills, and Abilities) Gap Analysis and Take Inventory of Partner Strengths

The implementing agency will need to identify core KSAs for successful CAV deployment and review whether they can be satisfied with current staff, developed in-house, or should be outsourced, as recommended in the culture, organization, and staffing dimension of the CAV CMF. While conducting this gap analysis, it is recommended to take inventory of applicable strengths of partner agencies. There are already external organizations preparing for CAVs (see Figure 13) and those aware of the technology (see Figure 12); this knowledge and experience should be leveraged. For example, one survey participant was involved in several national CAV efforts but was unaware of current LaDOTD CAV activities. Partner agencies may be able to fulfil some core KSAs—related to systems engineering, data management, V2I communication, etc.—but can be further utilized in maximizing benefits of implementation. For example, involvement from advocacy and disadvantaged groups will better ensure that all travelers are represented and impacts are equitably distributed. Local chambers of commerce may assist in promoting economic development from deployments. COAs provide access to aging communities and are a critical ally in improving mobility of the elderly. Although limited, partner agencies also have their own funding sources which may be advantaged. Strengths can be identified through participation in the above advisory council and forums—and will assist in identifying partner roles and responsibilities.

6.1.4. Conduct Pilot Demonstrations to Strategically Engage Stakeholders

There is no substitution for the experience gained from pilot CAV deployments and the resulting improvements across all the CAV CMF dimensions. Deployments should be based on solving specific safety, operational, or mobility challenges. However, pilot demonstrations can be further used as a mechanism to strengthen strategic partnerships or be tailored to key decision makers. Collaborative pilots require significant engagement and resources from primary partners and potentially their constituents. Collaborative pilots will better define partner's roles and responsibilities in each stage of the project lifecycle (in planning, preliminary and final design, construction, operation, and measuring performance). Of those involved, pilots will likely raise awareness, increase positive perception, and solidify the importance of preparing for CAV technologies (Questions 1, 2, 4, and 6). For example, collaborating with transit providers on a CAV pilot related to first-mile, last-mile transit or AV shuttles may shift agency characteristics from Group B to Group C.

6.1.5. Near-Term Actions (Survey Follow-Up)

Recommendations listed above require significant effort and time to execute. There are several, near-term activities that can be pursued to build upon the conducted survey—and inform strategies in accomplishing the above. For example, organizations who are currently preparing for CAV technologies (see Figure 13) can participate in a follow-up survey to determine specifically how they are preparing. Likewise, as organizations tended to select their own area being the most likely impacted by CAV technologies (see Figure 15), a follow-up survey can be conducted to determine in what ways they believe impacts will occur. This may assist in planning and programming CAV deployments. Focusing on identified areas of concern, the DOT may contact transit freight, and economic agencies in open dialogue and invite them to current DOT meetings and workshops. These agencies may also pilot developed educational materials. Although beneficial, gathered information in the conducted survey is limited. Follow-up surveys are recommend for deeper insights—and used in continual collection of stakeholder feedback.

6.2. Crash Analysis

To better align this study to current initiatives by LaDOTD's "CAV Technology Team", a CAV application of interest to the Team was selected for further analysis; QWS was chosen due to its prevalence in the CAV Action Plan. A crash analysis was conducted at each location specified in the Plan to determine if the proposed deployment scenarios are suitable candidates for QWS. The analysis utilized five-year historical crash data and focused on crash rate, severity level, manner of collision, and LOSS (for all crashes and F&SI crashes). The analysis was conducted in accordance with LaDOTD guidelines *(44, 45)*. Studied locations included: (1) a 4.470-mi segment of I-110 near the Governor's Mansion in East Baton Rouge Parish, (2) a 9.349-mi segment of I-10 near Louis Armstrong New Orleans International Airport in Jefferson Parish, (3) a 12.517-mi segment of I-10 in West Baton Rouge Parish, and (4) a 15.341-mi segment of I-12 in St. Tammany Parish. Primarily due to overrepresentation of rear-end crashes, QWSs may be suitable at the Jefferson Parish and West Baton Rouge Parish locations.

Ideally, some form of analysis should be conducted for each proposed CAV deployment—generally, but also for each effort specified in the CAV Action Plan. This study serves as an example of such analysis: evaluating CAV deployments using existing state DOT processes. It is likely not necessary to implement CV- or CAV-based systems at the recommended locations in order for the QWS to be effective; QWSs can be implemented with existing ITS architecture and technology as summarized in Subsection 3.2. Likewise, the analysis should be considered as the first step; a more detailed and comprehensive safety analysis should be conducted to properly recommend a QWS (or related system). This may include an evaluation of all state-owned roadways with overrepresented rear-end crashes, and with a set of defined criteria, ranking each segment's suitability.

6.3. AMS CAV Case Study

The projects/actions defined in the CAV Action Plan are selective and did not include mobility-based CAV applications. Thusly, they did not lend themselves to AMS. However, congestion is a wide-spread issue in urbanized areas across the U.S., negatively impacting system performance of both freeways and arterials. This is particularly true for Region 6 (AR, LA, NM, OK, and TX)—containing four cities in the top 25 "most congested U.S. cities" *(57)*. As shown in Figure 16, congestion trends in the Region continue to worsen: with four of the six regional cities being tracked in the latest FHWA "Urban Congestion Report", reporting an increase in congested hours, travel time index, and planning time index metrics *(58)*.

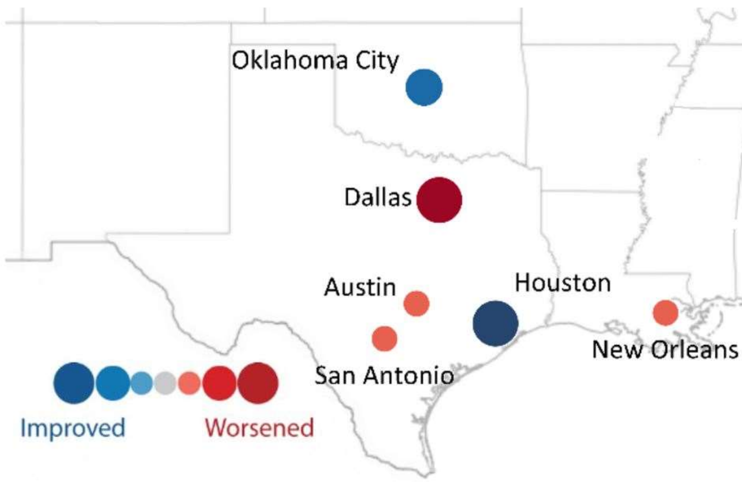


Figure 16. Snapshot of year-to-year congestion trends of the six tracked cities in Region 6 *(58)*.

Significant state- and national-level guidance exists on successfully implementing congestion mitigation strategies (for such strategies as integrated corridor management, innovative intersection and interchange designs, active demand management, intelligent transportation systems, etc.). CAVs can be integrated into such strategies to provide exceptional mobility benefits. For example, CACC, cooperative speed harmonization, and cooperative merging are applications that have shown to improve operational performance of freeway systems. Therefore, the research team recommends conducting AMS case studies investigating mobility-based CAV applications.

Due to discussions with LaDOTD staff outlined in Subsection 4.3, the research team also suggests utilizing a modeling network independent of those developed through a LaDOTD contract. To the best of our knowledge, the only such Louisiana network available (with appropriate geospatial limits) is one developed through a previous Tran-SET project *(59)*. The microsimulation network covers I-10 at the Mississippi River Bridge in Baton Rouge—extending from Lobdell Highway in Port Allen to Highland Road, I-110 to Florida Street, and I-12 to Walker Road). See Figure 17 for reference. Due to significant recurring congestion and series of complicated entrances/exits, this network is ideal to investigate multiple mobility-based CAV applications. This could include cooperative speed harmonization, cooperative on-ramp merging, lane speed monitoring systems, or other managed lane schemes (e.g., for CACC or truck platooning vehicles).

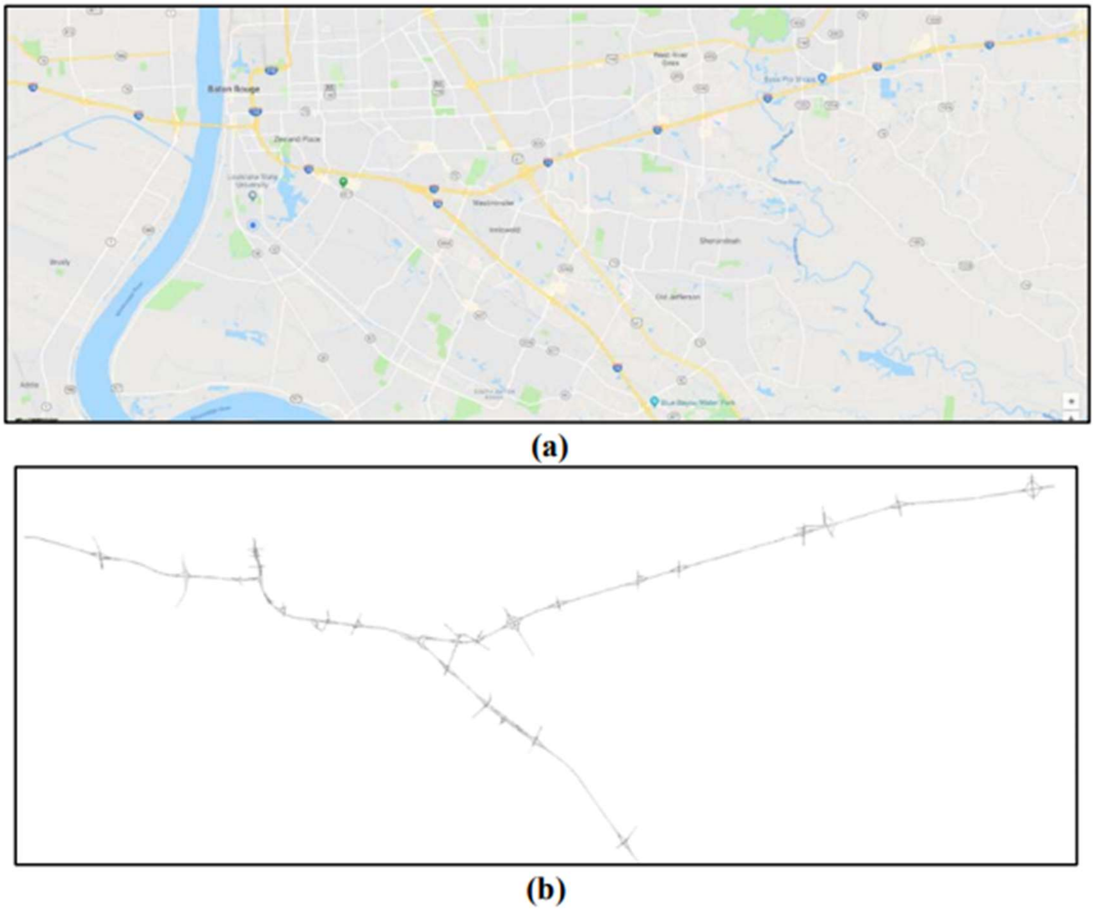


Figure 17. The study area in (a) Google Maps and (b) in the microsimulation model *(59)*.

6.4. Concluding Statement

In this study, the State of Louisiana and LaDOTD was used as a case study—representing agencies with no deployment experience who are currently investigating CAV technologies and beginning planning efforts. This is primarily true for the stakeholder survey (and related analyses), but also for the conducted crash analysis. Although brief and with limitations, it is our hope results will be utilized in current and future CAV preparatory actions—informing CAV-related policy, planning, and integration strategies at similar state DOTs.

REFERENCES

1. Zmud, J., G. Goodin, M. Moran, N. Kalra, and E. Thorn. (2017). “Advancing automated and connected vehicles: Policy and planning strategies for state and local transportation agencies”. NCHRP Research Report 845. National Cooperative Highway Research Program. (https://doi.org/10.17226/24872).

2. U.S. Congress (2015). Fast Act, H.R.22, Sec. 1430, 114th U.S. Congress.

3. FHWA (2016). “Development of an analysis-modeling-simulation (AMS) framework for V2I and connected and automated vehicle environment”. Contract no. DTFH61-16-D-0030-T-16003. Federal Highway Administration.

4. FHWA (2016). “Hardware in the loop testing of connected automated vehicle applications”. Contract no. DTFH61-16-D-0030-T-16011. Federal Highway Administration.

5. FHWA (2017). “Developing analysis, modeling, and simulation (AMS) tools for connected and automated vehicle (CAV) applications”. Contract no. DTFH61-16-D-0030-T-16022. Federal Highway Administration.

6. Rogers, E.M. (2010). *Diffusion of Innovations*. Simon and Schuster.

7. Chauhan, A. (2020, March). *DOTD CAV & Smart Mobility Updates: CAV Strategic Plan, Policy Formulation for LA AV Laws, CAV Technology Team Activities*. Presented at the Louisiana Transportation Conference 2020, Baton Rouge, LA.

8. Tran-SET (2021). *About Us.* Intelligent Transportation Consortium of South-Central States, Baton Rouge, LA. http://transet.lsu.edu/about-us/. Accessed May 4, 2021.

9. ITS-JPO (2021). *Connected Vehicle Applications.* Intelligent Transportation Systems Joint Program Office, Washington, DC. https://www.its.dot.gov/pilots/cv_pilot_apps.htm. Accessed May 4, 2021.

10. NHTSA (2019). “Automated vehicles for safety”. National Highway Traffic Safety Administration. https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety. Accessed Feb. 8, 2019.

11. FHWA (2017). “Partially automated truck platooning demonstration”. YouTube. Federal Highway Administration. https://youtu.be/iNTKqh7i5jQ. Accessed Feb. 8, 2019.

12. FHWA (2018). “Cooperative automation: Safely improving highway capacity”. YouTube. Federal Highway Administration. https://youtu.be/9Re__KRr4NU. Accessed Feb. 8, 2019.

13. FHWA (2016). “Paving the way to connected automation: GlidePath”. YouTube. Federal Highway Administration. https://youtu.be/I753gGLJAcg. Accessed Feb. 8, 2019.

14. FHWA (2016). “Paving the way to connected automation: Cooperative adaptive cruise control”. YouTube. Federal Highway Administration. https://youtu.be/2-WoV8nKQUE. Accessed Feb. 8, 2019.

15. Wilmot, C. and Greensword, M. (2016). *Investigation into Legislative Action Needed to Accommodate the Future Safe Operation of Autonomous Vehicles in the State of Louisiana*. Report No. 571, Louisiana Transportation Research Center, Baton Rouge, LA.

16. Sherif, I., Osman, O., Codjoe, J., Mousa S., and Bakhit, P. (2018). *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator*. Report No. 586, Louisiana Transportation Research Center, Baton Rouge, LA.

17. L.A. Legis. Assemb. (2018). *Act No. 310*. Reg. Sess. 2018.

18. L.A. Legis. Assemb. (2019). *Act No. 232*. Reg. Sess. 2019.

19. Otter, B. (2018). *Autonomous and Connected Vehicle Testing and Deployment Committee: Report to the Governor.* State of Idaho, Boise, ID.

20. LePage, P.R. (2018). *An Order Establishing the Maine Highly Automated Vehicles Advisory Committee*. Executive Order 2018-001, State of Maine, Augusta, ME.

21. N.E. Legis. (2018). *Authorize Automated-Driving-System-Equipped Vehicles, Automated Driving Systems, and Driverless-Capable Vehicles as Prescribed*. LB 989. 105th Legislator, Second Regular Session.

22. V.T. Gen. Assemb. (2019). *Automated Vehicle Testing Act*. 23 VSA Title 23, Chapter 41.

23. Iowa DOT (2019). *Cooperative Automated Transportation (CAT) Service Layer Plan*. Iowa Department of Transportation, Ames, IA.

24. Lopez, A., Rensel, E., Matkowski, L., Slizofski, A., McAliney, C., Kuhn, B., Balke, K., Shank, D., and Heise, C. (2018). *Pennsylvania Joint Statewide Connected and Automated Vehicles Strategic Plan*. Report No. FHWA-PA-2018-009-W022. Pennsylvania Department of Transportation, Harrisburg, PA.

25. Reshadi, A. (2019, October). *Current CAV Initiatives/Efforts in Wisconsin*. Presented at the Connected and Autonomous Vehicles Summit, Madison, WI.

26. Nylen, A. (2020). Connected and Autonomous Technology Program. Colorado Department of Transportation, Denver, CO. Accessed Jul. 19, 2020. https://www.codot.gov/programs/operations/intelligent-transportation-systems/innovation/connected-and-autonomous-technology-program.

27. Florida DOT (2019). *Florida's Connected and Automated Vehicles (CAV) Business Plan*. Connected and Automated Vehicles (CAV) Program, Florida Department of Transportation, Tallahassee, FL.

28. MDOT SHA (2020). *Connected and Automated Vehicle 2019 Accomplishments & The Road Ahead.* Connected and Automated Vehicle (CAV) Program, Maryland Department of Transportation State Highway Administration, Baltimore, MD.

29. Hamm, A. (2020). *Connected and Automated Vehicle Program*. Virginia Department of Transportation, Richmond, VA. Accessed Jul. 19, 2020. http://www.virginiadot.org/programs/connected_and_automated_vehicles.asp.

30. Pretorius, P., Burgess, L., Fowler, T., Dale, J., Townsend, D., Lewis, A., Good, A., and Lockwood, S. (2011). *Integrating Business Processes to Improve Travel Time Reliability*. Report No. S2-L01-RR-2. 2011. The Second Strategic Highway Research Program (SHRP2), National Academies of Sciences, Engineering, and Medicine, Washington, D.C.

31. Lockwood, S., Tarnoff, P., O'Laughlin, J., and Thatchenkery, T. (2012). *Institutional Architectures to Improve Systems Operations and Management*. Report No. S2-L06-RR-1. The Second Strategic Highway Research Program (SHRP2), National Academies of Sciences, Engineering, and Medicine, Washington, D.C.

32. Gopalakrishna, D., Serulle, N. U., Storer, T., Kuhn, B. T., and Wood, N. (2019). *Business Process Frameworks for Transportation System Management and Operations (TSMO) Program Areas: Case Studies and Lessons Learned from Users of Program Area Frameworks*. Report No. FHWA-HOP-19-011. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

33. AASHTO (2014). *AASHTO Transportation Systems Management and Operations Guidance*. American Association of State Highway Transportation Officials, Washington, D.C. Accessed Apr. 15, 2020. http://www.aashtotsmoguidance.org/.

34. FHWA (2017). *Smarter Work Zones: Overview of Queue Warning Systems*. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. Accessed May 5, 2021. https://www.workzonesafety.org/files/documents/SWZ/FHWA_overview_QWS.pdf.

35. Enterprise (2014). *Queue Warning Systems in Work Zones: Summary of Uses and Benefits*. Evaluation New Technologies for Roads Program Initiatives in Safety and Efficiency. TPF-5(359). https://enterprise.prog.org/Projects/2010_Present/iwz/QueueWarning_Summary_FINAL_June2014.pdf. Accessed May 5, 2021.

36. Study Tour Team (1999). *Innovative Traffic Control Technology and Practice in Europe*. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

37. Wiles, P. B., S. A. Cooner, C. H. Walters, and E. J. Pultorak (2003). *Advance Warning of Stopped Traffic on Freeways: Current Practices and Field Studies of Queue Propagation Speeds*. Texas Transportation Institute, Texas A&M University System, College Station, TX.

38. Ullman, G. L., V. Iragavarapu, and R. E. Brydia (2016). Safety Effects of Portable End-of-Queue Warning System Deployments at Texas Work Zones. *Transportation Research Record*, 2555, pp. 46–52. (https://doi.org/10.3141/2555-06).

39. Smith, S., Koopman, J., Rakoff, H., Peirce, S., Noel, G., Eilbert, A. and Yanagisawa M. (2018). *Benefits Estimation Model for Automated Vehicle Operations: Phase 2 Final Report*. Report No. FHWA-JPO-18-636. U.S. Department of Transportation, Joint Programs Office for Intelligent Transportation Systems, Washington, D.C.

40. Kockelman, K., Boyles, S., Avery, P., Claudel, C., Bansal, P., Loftus-Otway, L., and Clements, L. (2016). *Bringing Smart Transport to Texans: Ensuring the Benefits of a Connected and Autonomous Transport System in Texas*. Report No. FHWA/TX-16/0-6838-2, Texas Department of Transportation, Austin, TX.

41. Walker, S. (2018). *Report of the Governor's Steering Committee on Autonomous and Connected Vehicle Testing and Deployment*. State of Wisconsin, Madison, WI.

42. Gettman, D., Burgess, L., Haase, D., Flanigan, E., and Lockwood, S. (2017). *Guidelines for Applying the Capability Maturity Model Analysis to Connected and Automated Vehicle*

Deployment. Report No. FHWA-JPO-18-629. U.S. Department of Transportation, Joint Programs Office for Intelligent Transportation Systems, Washington, D.C.

43. Walz, T. (2018). *Governor's Advisory Council on Connected and Automated Vehicles: Executive Report*. State of Minnesota, Saint Paul, MN.

44. LaDOTD (2016). *Guidelines for Conducting a Crash Data Analysis using the Number-Rate Method and Overrepresented Determination*. Louisiana Department of Transportation and Development, Baton Rouge, LA.

45. LaDOTD (2016). *Guidelines for Conducting a Crash Data Analysis using Safety Performance Functions and Pattern Recognition Analysis*. Louisiana Department of Transportation and Development, Baton Rouge, LA.

46. Connors, M. (2015). *LaDOTD Highway Crash List*. Louisiana Department of Transportation and Development, Baton Rouge, LA.

47. Melson, C. (2021). *SimCap Louisiana: Promoting Best Practices in the Application of Traffic Simulation and Capacity Analysis*. Accessed May 7, 2021. https://simcap.eng.lsu.edu/.

48. ITE (2021). Simulation and Capacity Analysis User Group (SimCap). Institute of Transportation Engineers (ITE), Washington, D.C. Accessed May 7, 2021. https://www.ite.org/technical-resources/councils/traffic-engineering/simulation-and-capacity-analysis-user-group-simcap/.

49. Pettigrew, S., Talati, Z., and Norman, R. (2018). The health and benefits of autonomous vehicles: Public awareness and receptivity in Australia. *Australian and New Zealand Journal of Public Health*, 42(5), pp. 480-483.

50. FHWA (2018). Status of the Nation's Highway, Bridges, and Transit: Conditions and Performance, Part III: Highway Freight Transportation. *Report to Congress*, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

51. U.S.C. (2006). *Discovery and Admission as Evidence of Certain Reports and Surveys*. United State Code, Supplement 5, Title 23, Section 409.

52. L.A. (2019). *Manual for Use of the Uniform Traffic Crash Report*. State of Louisiana, Baton Rouge, LA. Accessed May 8, 2021.

53. NACo (2019). *Connected and Automated Vehicles Toolkit*. National Association of Counties, Washington, D.C. Accessed Apr. 15, 2020. https://www.naco.org/resources/featured/connected-autonomous-vehicles-toolkit.

54. NGA (2018). *Governor's Staying Ahead of the Transportation Innovation Curve: A Policy Roadmap for States*. National Governors Association, Washington, D.C. Accessed Apr. 15, 2020. https://www.nga.org/wp-content/uploads/2018/07/Transportation-Innovation-Roadmap-Final-Hi-Res-for-Posting-Online.pdf.

55. Hallmark, S., Veneziano, D., and Litteral, T. (2019). *Preparing Local Agencies for the Future of Connected and Autonomous Vehicles*. Report No. MN/RC 2019-18, Minnesota Department of Transportation: Local Road Research Board, St. Paul, MN.

56. Melson, C. (2020). *Connected and Automated Vehicles: Resources to Assist Local Agency Preparation*. Louisiana Local Technical Assistance Program, Baton Rouge, LA. Accessed May 8, 2021. https://www.ltrc.lsu.edu/ltap/cav.html.

57. INRIX (2017). "INRIX traffic hotspot study 2017". INRIX. http://inrix.com/press-releases/us-hotspots/. Accessed May 8, 2021.

58. FHWA (2017). "Urban congestion report (UCR): A snapshot of year-to-year congestion trends in the U.S. for October through December 2016". Federal Highway Administration. https://ops.fhwa.dot.gov/perf_measurement/ucr/. Accessed Feb. 8, 2019.

59. Ahmed, S.A., and Osman, O.A. (2018). *Mitigating Traffic Congestion on I-10 in Baton Rouge, LA: Supply- and Demand-Oriented Strategies and Treatments*. Report No. 19ITSLSU09, Transportation Consortium of South-Central State (Tran-SET), Louisiana State University, Baton Rouge, LA.

APPENDIX A: Summary of State DOT CAV-Related Preparatory Actions

Table A1 summarizes the main CAV-related preparatory actions taken by each state DOT. The list is not meant to be exhaustive; the intention is to place LaDOTD in context of national efforts. It comprises of only public-facing information and represents a "snapshot" in time (only up-to-date at the time of this study). See Subsection 3.1.2 for category definitions.

Table A1. CAV-related preparatory actions by state DOTs.

Agency	Category	Brief Summary
Alabama DOT	None	-
Alaska DOT	None	-
Arkansas DOT	None	-
Arizona DOT	Coordinated	• Issued executive order allowing operation of autonomous/self-driving vehicles on Arizona public roads; • Conducted CV work zone pilot; and • Conducting "Arizona Vehicle Program", a testbed investigating several CV applications.
California DOT	Coordinated	• Developed nation's first CV testbed; • Expanded testbed capabilities; • Purchased and applied new striping machine, specifically to assist AVs; • Administered CAV-related research projects; • Created "Connected & Automated Vehicle Infrastructure Development" branch and related research program.
Colorado DOT	Programmed	• Created CAV Technology program with dedicated Program Manager and defined mission and objectives *(26)*; • Built full-scale connected environment along I-70; • Equipped two main arterial corridors for the SPaT challenge; and • Established "Autonomous Mobility Task Force".
Connecticut DOT	None	-
Delaware DOT	Directed	• Issued executive order developing a CAV advisory council; • Developed planning documents for advisory council; • Implemented a connected corridor along US-13; and • Plan to establish a "Cooperative Automated Transportation Section".
Florida DOT	Programmed	• Developed business plan to establish an institutionalized framework and target schedule to move the CAV program from pilots into statewide deployment *(27)*; and • Leading several large CAV implementations: driver assisted truck platooning pilot, "Florida Automated Vehicles", "Florida's Connected Vehicle Initiative", "I-Street@UF", and "Suntrax".
Georgia DOT	Directed	• Completed research project to develop GDOT roadmap for driverless vehicles; and • Implemented large-scale deployment of DSRC at 400 locations, with plans for 1,000 new locations.
Hawaii DOT	None	-
Iowa DOT	Coordinated	• Created advisory council on automated transportation; • Conducting several pilots: I-380 as CAV proving grounds and HERE's HD Live Map Cloud Communications; and • Developed comprehensive cooperative automated transportation (CAT) service layer for their TSMO program *(23)*.

Agency	Category	Brief Summary
Idaho DOT	Undirected	• Executive order created the "Autonomous and Connected Vehicle Deployment Committee"; and • Committee developed a summarizing report *(19)*.
Illinois DOT	Coordinated	• Executive order created the "Autonomous and Connected Vehicle Deployment Committee" and "Autonomous Illinois Testing Program"; • CAVs addressed in their ITS architecture concept of operations; and • CAVs mentioned in their ITS strategic plan.
Indiana DOT	Directed	• CAVs discussed in multimodal freight plan; and • CAVs mentioned as major initiative in 2019 strategic plan.
Kansas DOT	Directed	• Developed statewide CAV vision plan; • Planning related pilots and ITS upgrades; and • Programmed CAV strategic plan development in upcoming fiscal year.
Kentucky DOT	None	-
Louisiana DOT	Directed	• Established internal CAV work group; and • Currently developing "CAV Strategic Plan" and "CAV Action Plan".
Maine DOT	Undirected	• Executive order established AV commission and AV pilot program *(20)*.
Maryland DOT	Programmed	• Established CAV working group; • Developed CAV action plan and related strategic plan; • Established new connected and automated transportation systems division; and • Developed roadmap of CAV efforts *(28)*.
Massachusetts DOT	Coordinated	• Executive order established AV working group and created process for testing of automated driving systems; • Developed strategic planning document; • Working group developed report on AV and testing program; and • Currently developing a formal strategic plan.
Michigan DOT	Coordinated	• Developed CAV technology strategic plan; • Developed CAV program strategic plan; • Recommended procedures to manage CAV data; • Established a CV testbed; and • Created the Michigan CAV work group.
Minnesota DOT	Coordinated	• Executive order created a CAV advisory council; • Developed CAV strategic plan; • Council conducted in-depth public engagement and developed executive report and report on CAV scenario planning *(43)*; • Established "Minnesota CAV Challenge RFP" and funded several projects; and • Established multiple test corridors.
Mississippi DOT	None	-
Missouri DOT	Directed	• Conducting several projects: driverless TMA (truck mounted attenuator), TTS-MoDOT CV project, and HAAS Alert/Makeway pilots.
Montana DOT	None	-
Nebraska DOT	Undirected	• Passed legislation that created a statewide policy authorizing the use of automated driving systems and driverless-capable vehicles *(21)*.

Agency	Category	Brief Summary
New Hampshire DOT	Directed	• Passed legislation allowing car manufacturers to test automated vehicles; • Developed CAV roadmap for deployment; and • Involved in several project-specific activities, including: assessing CAVs in long range transportation plans and implementing new signal controls.
New Jersey DOT	Undirected	• Piloting the use of beacon hazard lights technology to alert public of safety service vehicle, among others.
New Mexico DOT	None	-
Nevada DOT	Directed	• First state to pass legislation allowing AV testing; • Updated related legislation; and • Partnering with varied stakeholders to implement CAV pilots.
New York DOT	Directed	• Established "Autonomous Vehicle Testing and Demonstration" administrative process; • Mentioned CAVs in "Strategic Highway Safety Plan" and developed strategies to encourage CAV implementation; and • Participated in several CAV studies, including: eco-driving technologies for adaptive traffic signal control and investigating policy barriers of truck platooning.
North Carolina DOT	Coordinated	• Developed North Carolina CAV readiness roadmap; • Established AV committee; and • Established the "NC Transportation Center of Excellence on Connected and Automated Vehicle Technology" and will begin funding related research.
North Dakota DOT	Undirected	• Received federal grant to use innovative technology to improve work zone safety with an autonomous impact protection vehicle.
Ohio DOT	Programmed	• Established "DriveOhio", a single point of contact for all of Ohio's smart mobility initiatives; and • Involved in several large CAV efforts, including: "33 Smart Mobility Corridor", "Automated Driving Systems: SE Ohio", "Connected Marysville", "City Use Case in Development", "I-70 Truck Automation Corridor", "Smart Columbus", among others.
Oklahoma DOT	None	-
Oregon DOT	Directed	• Established AV task force; • Task force developed reports recommending related legislation; • Conducted research to develop a roadmap for CAV deployment scenarios; and • Established "Connected, Automated, and Electric Vehicles Advisor" position.
Pennsylvania DOT	Coordinated	• Developed "Connected and Autonomous Vehicle 2040 Vision"; • Established AV task force to recommend AV policy; • Developed AV testing guidance; • Developed "Highway Automated Vehicle Advisory Committee"; • Developed joint statewide CAV strategic plan *(24)*; and • Established "PennSTART" testing facility.
Rhode Island DOT	Directed	• Established "Rhode Island Transportation Partnership" for autonomous vehicle transit pilot program and implemented pilot.

Agency	Category	Brief Summary
South Carolina DOT	Directed	• Conducting project on the "Impact of Connected and Automated Vehicle Technologies on Statewide Long Term Transportation Program".
South Dakota DOT	None	-
Tennessee DOT	Coordinated	• Established "TennSMART", a consortium of organizations committed to shaping future intelligent mobility; • Funded several research projects, including: "Impacts and Adoption of Connected and Autonomous Vehicles in Tennessee" and "Research on Connected and Automated Vehicles Investment and Smart Infrastructure in Tennessee"; and • Plans to deploy DSRC along I-24.
Texas DOT	Coordinated	• Established the "Texas Innovation Alliance"; • Through legislation, established the "Texas Technology Task Force"; • Formed the "Texas AV Proving Ground Partnership"; and • Established the "Connected and Automated Vehicle Task Force", with the aim to be a one-stop resource for information and coordination among all ongoing CAV projects, investments, and initiatives in Texas.
Utah DOT	Coordinated	• Built first operational CV corridor in nation along Redwood Road; • Conducted autonomous shuttle pilot across state; and • Plan to install intelligent sensors along selected sections of state highways and implement connected fleet of state-owned vehicles.
Virginia DOT	Programmed	• Established CAV program plan and strategic roadmap of VDOT activities; • Established CAV program and dedicated program manager *(29)*; and • Established "Virginia Connected Corridor", "Virginia Automated Corridor", implemented several pilots and demonstrations, and developed related data portal.
Vermont DOT	Undirected	• Passed "Automated Vehicle Testing Act" and developed process to approve AV testing *(22)*.
Washington DOT	Coordinated	• Executive order established AV workgroup; • Developed cooperative automated transportation (CAT) policy framework; • Established CAT program (within their TSMO program) and related workgroup; and • Funded several pilot projects, including: traffic signal pilot, work zone safety pilot, and incorporating CAVs in long range planning.
West Virginia DOT	None	-
Wisconsin DOT	Coordinated	• Executive order established "Governor's Steering Committee on Autonomous and Connected Vehicle Testing and Deployment"; • Committee developed report *(41)*; • Established "Wisconsin AV Proving Grounds" and several testing facilities (with planned deployments); and • Bureau of Traffic Operations developed CV roadmap *(25)*.
Wyoming DOT	Undirected	• Awarded and conducting "Wyoming DOT Connected Vehicle Pilot".

APPENDIX B: Stakeholder Survey

The electronic survey is provided in full below. Text within brackets were not shown to participants and is meant to provide further context to the question.

Connected and automated vehicle (CAV) technologies offer potentially transformative and far-reaching impacts to the Louisiana transportation system – and other associated, reliant fields. This may include impacts to: public safety, congestion, personal mobility, land use, pollution and the environment, socio-economic characteristics, and the economy.

Please rate your organization's overall awareness of CAV technologies and their potential impacts:

- Very aware
- Somewhat aware
- Neither aware nor unaware
- Somewhat unaware
- Very unaware

Please rate your organization's overall perception of CAV technologies and their potential impacts:

- Very positive
- Somewhat positive
- Neither positive nor negative
- Somewhat negative
- Very negative

Please rank the top three (3) topical areas you believe will be most impacted by CAV technologies (in Louisiana): [Order of options were randomized]

- PUBLIC SAFETY: CAVs have the potential to reduce crashes caused by human error (such as distracted and impaired driving).
- CONGESTION: CAVs have the potential to increase traffic operational efficiency and lessen congestion (through select, specific deployment applications). However, vehicle miles traveled (VMT) may also increase during deployment of CAVs (potentially partially offsetting this benefit).
- PERSONAL MOBILITY: CAVs have the potential to increase mobility among non-driving populations (youth, elderly, and disabled) – and create new models of car sharing, ride-hailing, and other mobility-on-demand services.
- LAND USE: CAVs have the potential to impact the use of land for transportation functions (e.g., parking areas and road geometry) as well as longer term land use changes to community planning, location and density of housing, recreation areas, and others.
- POLLUTION AND THE ENVIRONMENT: CAVs have the potential to directly impact the environment through land use changes, reduction in transportation emissions, and others. The net impact to emissions and the environment is currently uncertain and will depend on adoption practices, policies, specific deployments, and other factors.
- SOCIO-ECONOMIC CHARACTERISTICS: Deployment of CAV technologies may be unevenly distributed geographically, socially, and economically. Although the technologies themselves may offer better access and inclusivity, their deployment may warrant oversight by policy makers to ensure equal distribution and access.

- ECONOMY: Deployment of CAV technologies may impact industries such as freight hauling, automotive and liability insurance, vehicle maintenance, law enforcement, health care, and others. It may require a new type of workforce: new jobs, skills, and training requirements. CAVs may impact economic opportunities for businesses, provide a more efficient supply chain, greater mobility to individuals, and greater access to effective transportation, job opportunities, and goods.

Please select the topical area that is most related to your organization's (or your division's) purview: [Order of options were randomized]

- Public safety
- Congestion
- Personal mobility
- Land use
- Pollution and the environment
- Socio-economic characteristics
- Economy

Please rate how likely you believe CAV technologies will provide a meaningful impact to your organization's (or your division's) purview:

- Very likely
- Somewhat likely
- Neither likely or unlikely
- Somewhat unlikely
- Very unlikely

Please estimate the most likely timeframe in which these meaningful impacts will occur: [Shown if response to the previous was "Very Likely" or "Somewhat Likely"]

- Long-term: beyond 10 years from now
- Mid-term: 4-10 years from now
- Short-term: 0-4 years from now

Is your organization (or division) currently planning or preparing for CAV technologies and their potential impacts?

- Yes
- No

Please rate how important it is for your organization (or division) to plan and prepare for CAV technologies and their potential impacts:

- Very important
- Somewhat important
- Neither important or unimportant
- Somewhat unimportant
- Very unimportant

Please indicate your organization's type: [Depicted as a dropdown list]

- Academic institution

- Government agency (local)
- Government agency (regional)
- Government agency (state)
- Government agency (federal)
- Nonprofit
- Private industry

(Optional) Are you interested in learning more about this research project and keeping abreast of its progress? [Optional question]

- Yes
- No

(Optional) Please enter your e-mail address. You may receive pertinent information or periodic status updates regarding this project. Note: your e-mail address will only be used for this purpose and kept confidential. Your survey responses will remain anonymous. [Optional question; shown if response to the previous was "Yes"]

Thank you for completing the survey. Please feel free to contact the Principal Investigator, Christopher Melson, at cmelson1@lsu.edu with any inquiries – or if you would like to provide more detailed feedback. You may also visit melsatron.com for additional project information.

APPENDIX C: Contacted Organizations for Survey Participation

The complete list of organizations that were contacted for the survey is shown in Table C1.

Table C1. Each agency contacted to complete the survey.

Functional Category	Organizations	
Aging Communities	Acadian Council on Aging[L] Allen Council on Aging[L] Ascension Council on Aging[L] Assumption Council on Aging[L] Avoyelles Council on Aging[L] Beauregard Council on Aging[L] Bienville Council on Aging[L] Bossier Council on Aging[L] Caddo Council on Aging[L] CAJUN Area Agency on Aging[L] Calcasieu Council on Aging[L] Caldwell Council on Aging[L] Cameron Council on Aging[L] Catahoula Council on Aging[L] CENLA Area Aging[L] Claiborne Council on Aging[L] Concordia Council on Aging[L] Corporation for National and Community Service: Louisiana[F] Capital Area Agency on Aging[L] DeSoto Council on Aging[L] East Baton Rouge Council on Aging[L] East Carrol Council on Aging[L] East Feliciana Council on Aging[L] Evangeline Council on Aging[L] Franklin Council on Aging[L] Grant Council on Aging[L] Governor's Office of Elderly Affairs[S] Iberia Council on Aging[L] Iberville Council on Aging[L] Jackson Council on Aging[L] Jefferson Council on Aging, Inc.[L] Jefferson Davis Council on Aging[L] Lafayette Council on Aging[L] LaSalle Council on Aging[L] Lincoln Council on Aging[L]	Livingston Council on Aging[L] Louisiana Department of Health: Office of Aging and Adult Service[S] Madison Council on Aging, Inc.[L] Morehouse Council on Aging, Inc.[L] Natchitoches Council on Aging, Inc.[L] New Orleans Council on Aging, Inc.[L] North Delta Regional Planning & Development District[L] Ouachita Council on Aging[L] Pointe Coupee Council on Aging[L] Rapides Council on Aging[L] Red River Council on Aging, Inc.[L] Richland Council on Aging, Inc.[L] Sabine Council on Aging, Inc.[L] St. Bernard Council on Aging, Inc.[L] St. Charles Council on Aging[L] St. Helena Council on Aging[L] St. James Area Council on Aging[L] St. John Council on Aging, Inc.[L] St. Landry Council on Aging[L] St. Martin Council on Aging[L] St. Mary Council on Aging[L] St. Tammany Council on Aging, Inc.[L] Tangipahoa Voluntary Council on Aging[L] Tensas Council on Aging, Inc.[L] Terrebonne Council on Aging, Inc.[L] Union Council on Aging[L] Vermilion Council on Aging[L] Vernon Council on Aging[L] Washington Council on Aging[L] Webster Council on Aging, Inc.[L] West Baton Rouge Council on Aging[L] West Carroll Council on Aging, Inc.[L] West Feliciana Council on Aging[L] Winn Council on Aging[L]
Advocacy Groups	Beloved Community[N] Bike Easy[N] Foundation for Louisiana[N] Huey and Angelina Wilson Foundation[N] Louisiana Association of Business and Industry[N]	Louisiana Association of United Ways[N] Louisiana Budget Project[N] Middlebury Institute[N] Power Coalition for Equity and Justice[N] The Bridge Agency[N] Together Louisiana[N] Urban League of Louisiana[N]
Disadvantaged Groups	Advocacy Center of Louisiana[N] Arc Baton Rouge[N] Assumption Arc[N] Beauregard Arc[N] Catahoula Arc[N] Donaldsonville Area Arc[N]	St. James Arc[N] St. John Arc[N] St. Mary Arc[N] Statewide Independent Living Council Terrebonne Arc[N] The Arc: Caddo-Bossier[N]

Functional Category	Organizations	
	Governor's Office of Disability Affairs[S] Lafource Arc[N] LARC, Inc. [N] Lighthouse Louisiana[N] Louisiana Commission for the Deaf[S] Louisiana Department of Health: Office of Citizens with Developmental Disabilities[S] Louisiana Developmental Disabilities Council[S] People First of Louisiana[N]	The Arc: Iberville and West Baton Rouge[N] The Arc of Acadiana[N] The Arc of Greater New Orleans[N] The Arc of Louisiana[N] The Arc of Morehouse[N] The Arc of Ouachita[N] The Arc of Sabine[N] The arc of St. Charles[N] The Arc of St. Martin[N] The Arc of Vermillion[N] The Arc of Rapides[N]
Economic Development	Acadiana Planning Commission[L] Baton Rouge Area Chamber[L] Capital Region Planning Commission[L] Central Louisiana Economic Development Alliance[L] Committee of 100 for Economic Development, Inc.[N] Greater New Orleans Business Alliance[L] Greater New Orleans, Inc.[L] Greater Shreveport Chamber[L] Lafayette Economic Development Authority[L] Louisiana Economic Development: Department of State Economic Competitiveness[S]	Louisiana Economic Development: Automotive Group[S] Louisiana Industrial Development Executives Association[N] Louisiana Public Facilities Authority[S] Louisiana Workforce Commission: Office of Workforce Development[S] New Orleans Chamber[L] North Louisiana Economic Partnership[L] One Acadiana[L] Public Affairs Research Council of Louisiana[N] Regional Planning Commission[L] South Louisiana Economic Council[L] Southwest Louisiana Economic Development Alliance[L] St. Tammany Corporation[L]
Environmental Quality	Baton Rouge Environmental Services[L] Federal Highway Administration[F] Greater New Orleans Foundation[N] Keep Greater Lake Charles Beautiful[L] Lafayette Environmental Quality Division[L] Louisiana Association of Business and Industry[N] Louisiana Association of Environmental Professionals[N] Louisiana Department of Environmental Quality: Acadiana Regional Office[L] Louisiana Department of Environmental Quality: Capital Regional Office[L] Louisiana Department of Environmental Quality: Division of Air Planning and Assessment[S]	Louisiana Department of Environmental Quality: Northeast Regional Office[L] Louisiana Department of Environmental Quality: Northwest Regional Office[L] Louisiana Department of Environmental Quality: Southeast Regional Office[L] Louisiana Department of Environmental Quality: Southwest Regional Office[L] Louisiana Department of Health: Environmental Public Health Tracking[S] Louisiana Environmental Action Network[N] Louisiana Environmental Health Association[N] Louisiana Natural Resources Conservation Service[S] Shreveport Environmental Services[L]
Freight	Acme Trucking Line, Inc.[I] Alexandria International Airport[L] Baton Rouge Metropolitan Airport[L] Berard Trucking[I] Dedicated Transportation, LLC[I] Gentry Trucking[I] Grand Isle Port Commission[L] Greater Lafource Port Commission[L]	Plaquemines Port[L] Point of Terrebonne[L] Port NOLA[L] Port of Delcambre[L] Port of Iberia[L] Port of Krotz Springs[L] Port of Lake Charles[L] Port of Lake Providence[L]

Functional Category	Organizations	
	J.H. Walker[I] Jensen Companies[I] LA-1 Coalition[N] Lafayette Regional Airport[L] Lake Charles Regional Airport[L] Louisiana Department of Transportation and Development: Commercial Trucking Program[S] Louisiana Motor Transportation Association[N] Louisiana Public Service Commission[S] Monroe Regional Airport[L] Natchitoches Parish Port[L] Ouachita Terminals[L]	Port of Morgan City[L] Port of South Louisiana[L] Port of Vermillion[L] Port of Vidalia[L] Port of Vinton[L] Porto of West St. Mary[L] Regional Planning Commission[L] Shreveport Regional Airport[L] St. Bernard Port, Harbor, & Terminal District[L] Starsky Robotics[I] Statewide Transport, Inc.[I] The Port Caddo-Bossier[L] United Vision Logistics[I] West Calcasieu Port[L]
Planning	Acadiana Planning Commission[L] American Planning Association: Acadiana Section[N] American Planning Association: Capital Section[N] American Planning Association: Louisiana[N] American Planning Association: Metro New Orleans Section[N] American Planning Association: North Louisiana Section[N] Baton Rouge Planning Commission[L] Capital Region Planning Commission[L] Coordinating & Development Corporation[L] Downtown Development District New Orleans[N] Federal Highway Administration[F]	Imperial Calcasieu Regional Planning & Development Commission[L] Kisatchie-Delta Regional Planning & Development Commission[L] Lafayette Planning Commission[L] Lake Charles Planning Development[L] Louisiana Department of Transportation and Development: Transportation Planning Group[S] Louisiana Division of Administration: Office of Community Development[S] Louisiana Municipal Association[N] MidCity Redevelopment Alliance, Inc.[N] New Orleans Planning Commission[L] Regional Planning Commission[L] Shreveport Community Development[L] Urban Land Institute Louisiana[N]
Public Safety	Acadian Regional Transportation Safety Coalition[L] Capital Region Transportation Safety Coalition[L] CenLA Highway Safety Coalition[L] Federal Highway Administration[F] Louisiana Center for Transportation Safety[S] Louisiana Department of Transportation and Development: Highway Safety Section[S] Louisiana Highway Safety Commission[S]	Louisiana Highway Safety Research Group[S] Louisiana Local Road Safety Program[S] New Orleans Regional Traffic Safety Coalition[L] North Shore Regional Safety Coalition[L] Northeast LA Highway Safety Partnership[L] Northwest LA Transportation Safety Coalition[L] South Central Regional Safety Coalition[L] Southwest LA Regional Safety Coalition[L]
Traffic Operations	Acadiana Planning Commission[L] Arcadis[I] Capital Region Planning Commission[L] City of Baton Rouge[L] City of Lafayette[L] City of Lake Charles[L] City of New Orleans[L] City of Shreveport[L] Federal Highway Administration[F]	ITS Answers[I] Louisiana Department of Transportation and Development: Traffic Engineering Division[S] Neel-Schaffer[I] North Delta Regional Planning & Development District[L] Rapides Area Planning Commission[L] Serco[I]

Functional Category	Organizations	
	Gresham Smith[I] Houma-Thibodauz MPO[L]	Urban Systems[I] Vectura[I] WSP[I]
Transit	Alexandria Transit (ATRANS)[L] Capital Area Transit Systems (CATS)[L] City of Lake Charles Transit[L] Federal Highway Administration[F] Good Earth Transit[L] Jefferson Transit[L] Louisiana Department of Transportation and Development: Public Transportation Program[S]	Lafayette Transit System[L] LSU Tiger Trails Transit System[L] Monroe Transit[L] New Orleans Regional Transit Authority[L] River Parish Transit Authority[L] Shreveport Area Transit System[L] St. Bernard Urban Rapid Transit[L] West Ouachita Public Transit[L]

[F]Federal agency; [I]Private industry; [L]Local agency; [N]Nonprofit; [S]State agency