Detailed Analysis of ADS-Deployment Readiness of the Existing Traffic Laws and Regulations

October 2020 Publication Number: FHWA-HOP-20-013

U.S. Department of Transportation
Federal Highway Administration

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-HOP-20-013		

4. Title and Subtitle Detailed Analysis of ADS-Deployment Readiness of the Existing Traffic Laws and Regulations	**5. Report Date** October 2020 **6. Performing Organization Code**
7. Author(s) Jiaqi Ma, Kyle Garrett, Abby Morgan	**8. Performing Organization Report No.**
9. Performing Organization Name and Address Leidos Inc. 11251 Roger Bacon Drive Reston, VA 20190 University of Cincinnati Synesis Partners LLC Kittelson & Associates Inc.	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** 693JJ319F000345
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 20590	**13. Type of Report and Period Covered** Technical Report July 2020 – October 2020 **14. Sponsoring Agency Code** HOP

15. Supplementary Notes

Government Task Manager: Kingsley Azubike

16. Abstract

This research investigates the challenges of establishing an automated driving system (ADS)-ready traffic laws and regulations database, as well as proposes access and exchange requirements to support sharing and consumption of the information within the ADS ecosystem. It alsodescribes the basic requirements for collaboration among State and local traffic code stakeholders, as well as ADS behavior subject matter experts. This report looks at currently available data that support automated vehicle integration into our roadway system, and investigates the issue of inconsistencies in basic traffic laws across the nation and how they affect ADS behavior. The report also identifies constraints and recommends solutions.

17. Key Words	18. Distribution Statement
automated driving system (ADS); traffic laws and regulations; Uniform Vehicle Code (UVC); automated vehicle; database	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	48	n/a

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)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°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^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	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	°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

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAA	American Automobile Association
ADS	automated driving system
ARTBA	American Road and Transportation Builders Association
AV	automated vehicle
BAC	blood alcohol content
CADS	cooperative automated driving system
CAT	Cooperative Automated Transportation
CDA	cooperative driving automation
CEO	chief executive officer
COU	concept of use
CV	connected vehicle
DAVI	Data for Automated Vehicle Integration
DC	District of Columbia
DOT	department of transportation
DUI	driving under the influence
DWI	driving while intoxicated
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standards
HOV	high-occupancy vehicle
HTML	Hypertext Markup Language
I2V	infrastructure-to-vehicle
I2V/V2I	infrastructure-to-vehicle/vehicle-to-infrastructure
IaC	infrastructure as code
IOO	infrastructure owner-operator
ITS–JPO	Intelligent Transportation System Joint Program Office
LiDAR	light detection and ranging
MUTCD	Manual on Uniform Traffic Control Devices
MVP	minimum viable product
NCHRP	National Cooperative Highway Research Program
NCSL	National Council of State Legislatures
NCUTLO	National Committee on Uniform Traffic Laws and Ordinances

NDAA	National District Attorneys Association
NHTSA	National Highway Transportation Safety Administration
O&M	ownership and maintenance
OBU	onboard unit
ODD	operation design domain
OEM	original equipment manufacturer
PDF	portable document format
RTF	rich text format
SAE	formerly, the Society of Automotive Engineers
SME	subject matter expert
SPaT	signal phase and timing
TMC	traffic management center
TSMO	transportation system management and operations
USDOT	U.S. Department of Transportation
UVC	Uniform Vehicle Code
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
VSL	variable speed limit
WZAD	Work Zone Activity Data
WZDI	Work Zone Data Initiative
WZDx	Work Zone Data Exchange
XML	Extensible Markup Language

CHAPTER 1. INTRODUCTION

This chapter provides the background and purpose of the research project and this report as well as the organization of the report.

BACKGROUND

The advent of automated driving systems (ADS) and automated vehicles (AV) will transform the way vehicles interact not only with each other and other travelers, but also with our transportation infrastructure, communications infrastructure, information systems, and system management and operations strategies. Infrastructure owner-operators (IOO) and their partner agencies across the country have been grappling with the questions of how ADS will interact with the transportation system—and what they should do to prepare. Uncertainty around the timing of ADS technology development and market penetration has made preparing for this transformation a challenge, underscoring the need for practice-ready information and tools that IOOs can use for planning and deploying resources and policies for integration of ADS. Key insights from the National Dialogue on Highway Automation[1] include a need for a national vision; increased public awareness and support; agency guidance and education; enhanced planning to include probabilistic and scenario-based planning; and data exchange, standardization, and management.

National automation readiness requires a strategic understanding of the context of automated vehicles and the national transportation infrastructure. The Federal Highway Administration (FHWA) has been exploring this context through the automated vehicle (AV) 3.0 initiative, information and data needs for AV, the National Dialogue on Highway Automation, and other FHWA leadership and working groups. Needs, insights, and opportunities identified through these efforts, as well as coordination with the Cooperative Automated Transportation (CAT) Coalition and other professional and research organizations, are providing essential input for Federal, State, and local initiatives to guide AV implementation. IOOs urgently need insights and tools for planning, developing, and deploying resources as they prepare their organizations, physical assets, and policies to best facilitate and leverage ADS deployment.

Among the key aspects of ADS planning, deployment, and operations, access to data is a critical enabler of safe, efficient, and accessible integration of AVs into the transportation system. On Thursday, December 7, 2017, the U.S. Department of Transportation (USDOT) hosted the Roundtable on Data for Automated Vehicle Safety.[2] The roundtable demonstrated multimodal alignment around the "One DOT" approach to Federal AV policy and marked the beginning of a new phase of dialogue with public and private sector stakeholders to accelerate the safe deployment of AVs.

---

[1] "National Dialogue on Highway Automation." National Dialogue on Highway Automation - FHWA Office of Operations. Accessed May 11, 2020. https://ops.fhwa.dot.gov/automationdialogue/index.htm.

[2] "Roundtable on Data for Automated Vehicle Safety Summary Report: US Department of Transportation," accessed May 11, 2020, https://www.transportation.gov/av/data/roundtable-data-automated-vehicle-safety-summary-report.

The following are high-priority use cases for data exchange:

- Monitoring planned and unplanned work zones.
- Providing real-time road conditions.
- Diversifying AV testing scenarios.
- Improving cybersecurity for AVs.
- Improving roadway inventories.
- Developing AV inventories.
- Assessing AV safety features and performance.

A data system related to traffic laws and regulations will facilitate the development of ADS behavior and roadway adaptations that fulfill the vision of safe and effective ADS operations.

Having consistent and accurate information about jurisdictional traffic regulations relates to ADS compliance that will support safe operations and performance on public roadways. The ADS Operational Behavior and Traffic Regulation Database framework is, therefore, a key component for realizing effective, robust digital transportation systems for AV integration. It consists of a comprehensive, structured database of traffic regulations that developers could use to set basic programming standards regarding traffic regulations.

There are challenges to developing ADS to account for the multitude of static and dynamic traffic regulations, providing the regulatory information to ADS, and determining how the system would be implemented across the nation. Traffic regulation information varies among jurisdictions across the country in format, structure, and implementation. Without common data exchanges, it is almost impossible to develop ADS software that can ensure optimal ADS performance under varying sets of traffic regulations. In short, ADS developers have indicated a need for a traffic regulation database that supports consistent indication of traffic regulation. This traffic regulation database will assist in the development, testing, and and later operation of ADS that is compliant with jurisdictional traffic laws resulting in safe ADS operational behavior.

PURPOSE

This research investigates the challenges of establishing an ADS-ready traffic laws and regulations database, and the access and exchange requirements to support sharing and consumption of the information within the ADS ecosystem. It also identifies the basic requirements for collaboration among State and local traffic code stakeholders, as well as ADS behavior subject matter experts (SME).

For consistency and interoperability, and to support other databases of existing traffic regulations and their interaction with ADS, it is necessary to develop a comprehensive database framework to support the incorporation of all traffic regulations that enable ADS behavior development and operation. The ultimate goal is to facilitate a standardized approach to developing traffic regulation specification that supports development and subsequent operations of traffic with ADS-equipped vehicles. This project involves detailed analysis of ADS readiness of the current traffic laws and regulations databases, development of a concept of use (COU), design of a prototype of the traffic laws and regulation database framework, conduct of a simulated proof-of-concept laboratory testbed-simulated demonstration, and development of a model testing plan for a future collaborative implementation of AV integration with the traffic laws and regulations database framework.

This report aims to leverage prior and current activities and milestones on data that support AV integration into our roadway system and investigate basic traffic laws, the issue of inconsistencies across the nation, and how this affects ADS behavior. The report aims to identify existing traffic laws and traffic regulation databases, and document an inventory of their data formats, elements, framework structure, and associated interfaces. This report also assesses the status of the Uniform Vehicle Code (UVC) and determines if the most recent update of the code could be resurrected and transformed into requisites for ADS behavior development. The report also identifies constraints and recommends solutions.

The organization of the report is as follows:

Chapter 1 introduces the background and purpose of the research project and this report.

Chapter 2 introduces national highway automation and ADS technologies and behavior.

Chapter 3 provides an overview of traffic laws and regulations and identifies existing traffic laws and traffic regulation databases, if any, or current forms and inventory of traffic regulation data.

Chapter 4 introduces UVC chapter 11 and its variations and inconsistencies across State and local jurisdictions.

Chapter 5 provides an assessment of existing traffic laws and regulation databases, identifies constraints and limitations, and recommends solutions from the perspective of design, deployment, and digital technology systems.

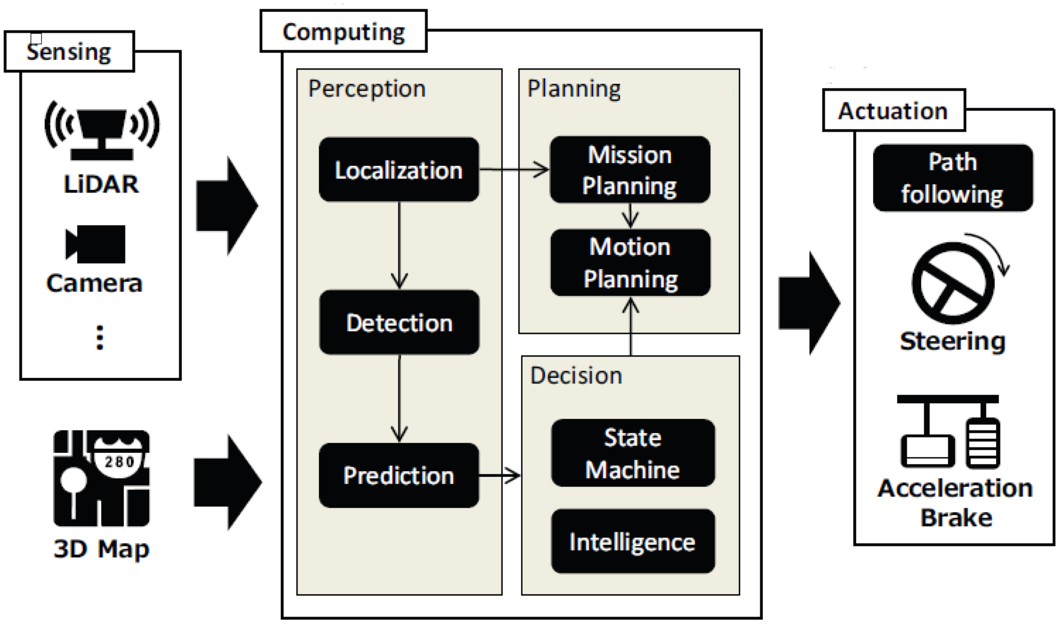
CHAPTER 2. AUTOMATED DRIVING SYSTEMS AND HIGHWAY AUTOMATION

This chapter introduces national highway automation and automated driving systems (ADS) technologies and behavior.

AUTOMATED DRIVING SYSTEMS AND BEHAVIOR

As cyber-physical systems, ADS-equipped vehicles can be abstracted into sensing, computing, and actuation modules, as shown in figure 1. Sensing devices, such as laser scanners (light detection and ranging [LiDAR]) and cameras, are typically used for driving automation in urban areas. Actuation modules handle steering and throttle, and the trajectory planning and tracking module typically generate the control commands. Computation is a major component of self-driving technology. Scene recognition, for instance, requires the localization, detection, and prediction modules, whereas path planning is handled by mission- and motion-based modules. Each module employs its own set of algorithms. Combined, the modules are exemplified by the well-known open-source automated driving software, Autoware™. Figure 1 shows the basic control and data flow for an autonomous vehicle. Sensors record environmental information that serves as input data for the artificial intelligence core, which includes data fusion for vehicle localization based on filtering techniques, machine learning methods for predicting other vehicle's behavior, and intelligent decision-making in mission/motion planning using optimal control or reinforcement learning approaches. Three-dimensional maps are becoming commonplace for self-driving systems, particularly in urban areas, as a complement to the planning data available from sensors. External data sources can improve the accuracy of localization and detection without increasing the complexity of the vehicle's algorithms. Artificial intelligence cores typically output values for angular and linear velocities, which serve as commands for steering and braking, respectively.

Another important concept related to ADS operational behavior is the operation design domain (ODD). In SAE's definitions of automation levels, a driving mode is a type of driving scenario with specific dynamic driving task requirements (e.g., expressway merging, high-speed cruising, low-speed traffic jam, and closed-campus operations). In SAE's levels of driving automation, shown in Figure 2, a particular shift occurs from SAE Level 2 to SAE Level 3: the human driver no longer has to actively drive when the corresponding automated driving features are activated. This is the final aspect of the dynamic driving task that is now passed over from the human to the automated system. At SAE Level 3, the human driver still has the responsibility to intervene when asked to do so by the automated system. At SAE Level 4, the human driver is relieved of that responsibility, and at SAE Level 5, the automated system will never need to ask for an intervention.



Source: Autoware[3]

Figure 1. Diagram. Automated driving vehicle platform (Autoware).

[3] "Wiki Autoware Foundation / Autoware.AI / Autoware," GitLab, accessed May 11, 2020, https://gitlab.com/autowarefoundation/autoware.ai/autoware/-/wikis/home.

SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You **are driving** whenever these driver support features are engaged - even if your feet are off the pedals and you are not steering			You **are not driving** when these automated driving features are engaged - even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests you must drive	These automated driving features will not require you to take over driving	
	THESE ARE DRIVER SUPPORT FEATURES			THESE ARE AUTOMATED DRIVING FEATURES		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/ acceleration support to the driver	These features provide steering AND brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• Automatic emergency breaking • Blind spot warning • Lane departure warning	• Lane centering OR • Adaptive cruise control	• Lane centering AND • Adaptive cruise control at the same time	• Traffic jam chauffeur	• Local driverless taxi • Pedals/steering wheel may or may not be installed	• Same as level 4, but feature can drive everywhere in all conditions.

Source: © 2020 SAE International. The summary table may be freely copied and distributed provided SAE International and J3016 are acknowledged as the source and must be reproduced AS-IS.[4]

Figure 2. Illustration. SAE International definition of levels of automation.

Based on the understanding of ADS software structure, any ADS component under different rules and regulations can affect ADS operational behavior. For example, yellow signal legends and timing may vary along and among urban corridors, such that when an AV detects a yellow light, how it interprets the rule may be dramatically different, which will then change the time when the vehicle can pass the stop bar at the intersection and, in turn, have an effect on the trajectory planning process of the AVs. Another example involves use of the left-most lane on freeways (e.g., overtaking only or regular driving). If the lane can only be used as an overtaking lane, the ADS planning module will always ask the vehicle to change back to the original lane after it passes the front slow-moving vehicle. Compared with the other condition (i.e used as regular driving lane), this traffic rule will potentially result in frequent lane-change behavior on freeways, causing inefficient traffic operations, demonstrating that different traffic laws and regulations may result in dramatically different ADS behaviors, even with the same ADS software. It is critical to provide ADS vehicles with accurate traffic regulation information and to

[4] "SAE International Releases Updated Visual Chart for Its 'Levels of Driving Automation' Standard for Self-Driving Vehicles," SAE International®, December 12, 2018, https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles.

design ADS software to explicitly incorporate the regulations to ensure safe and efficient behavior.

Additionally, ADS only involves single-vehicle automation through onboard sensing and computing. However, SAE is working on a new standard, J3216,[5] to define cooperative driving automation (CDA), which enables and supports ADS automation through machine-to-machine communications. In fact, CDA becomes even more relevant when traffic regulation databases are shared with AVs enabled with CDA to communicate this information. FHWA CARMA[SM] research vehicles, shown in Figure 3, are designed using open-source software to test CDA concepts to improve transportation system management and operations (TSMO) using CARMA Cloud[SM], a cloud-based framework. Figure 4 shows the CARMA program paradigm, which enables collaboration among industry, academia, IOOs, and public agencies on cooperative automation applications. Information from databases of traffic regulations can be shared with ADS-equipped vehicles enabled with CDA through vehicle-to-infrastructure (V2I) communication.

Source: FHWA

Figure 3. Photo. CARMA vehicles.

[5] https://www.sae.org/standards/content/j3216/.

Source: FHWA

Figure 4. Illustration. CARMA program paradigm.

The U.S. Department of Transportation (USDOT) has facilitated agreements among industry and non-Federal governments on common data formats that lower the cost of data exchange. This process for rapid deployment of an open data specification has been modeled on the General Transit Feed Specification,[6] which enables third parties and USDOT to access consistent transit data across the nation. This model encourages incremental adoption of data elements from the broader specification documented in the Work Zone Activity Data (WZAD) dictionary developed through FHWA's Work Zone Data Initiative (WZDI),[7] which addresses the role of these data in use cases spanning the entire project delivery life cycle.

USDOT launched Data for Automated Vehicle Integration[8] (DAVI) as an initiative to identify, prioritize, monitor, and, where necessary, address data exchange needs for AV integration across the modes of transportation. Access to data is a critical enabler of safe, efficient, and accessible integration of AVs into the transportation system. Lack of access to data could impede AV integration and delay safe introduction. In December 2017, USDOT hosted the Roundtable on Data for Automated Vehicle Safety to discuss potential priorities for voluntary data exchanges to

---

[6] http://gtfs.org/.

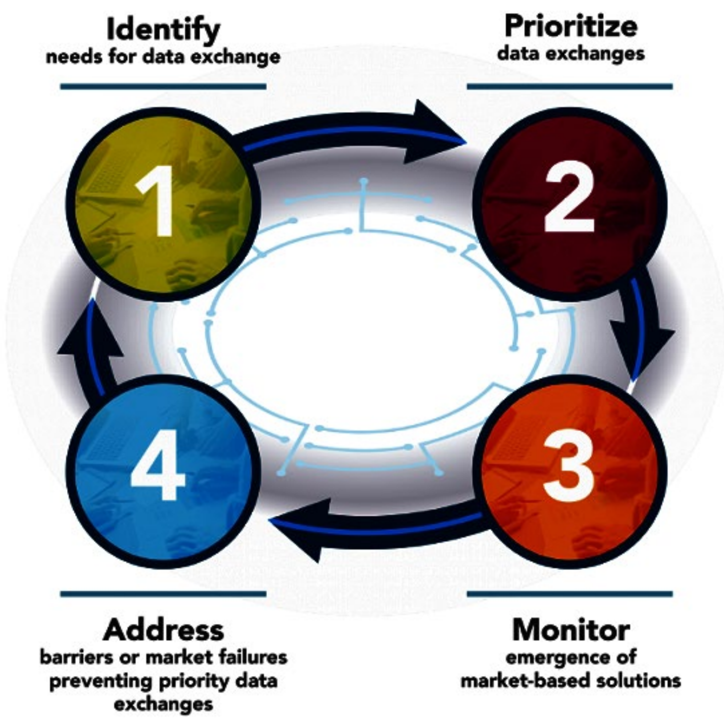
[7] https://ops.fhwa.dot.gov/publications/fhwahop18083/index.htm.

[8] https://www.transportation.gov/av/data.

accelerate safe AV integration. The department kicked off the Work Zone Data Exchange[9] (WZDx) project in March 2018 to take on one of the priorities identified at the roundtable. The summary notes also call for enhanced inventories for roadways, which include high-definition maps already being developed. Developing inventories of fixed objects on the road, such as traffic signs, is not a difficult task and it has been done for many locations by the private sector. The rules behind the infrastructure (i.e., traffic laws and regulations) also need to be part of the map. Unfortunately, no complete digital database exists that addresses this key issue.

Data for Automated Vehicle Integration

The USDOT DAVI framework provides a common language for identifying and prioritizing data exchange needs across traditional silos. It is designed to help stakeholders working on diverse aspects of AV integration understand each other's data needs and learn from successful exchanges as they emerge. The framework defines key categories, goals, participants, and priorities of data exchanges identified by the department's stakeholders, such as work zone data needed for AVs to navigate safely. USDOT continues to refine and update the framework based on stakeholder inputs.



Source: USDOT[10]

[9] "Work Zone Data Exchange (WZDx)," U.S. Department of Transportation, accessed May 11, 2020, https://www.transportation.gov/av/data/wzdx.

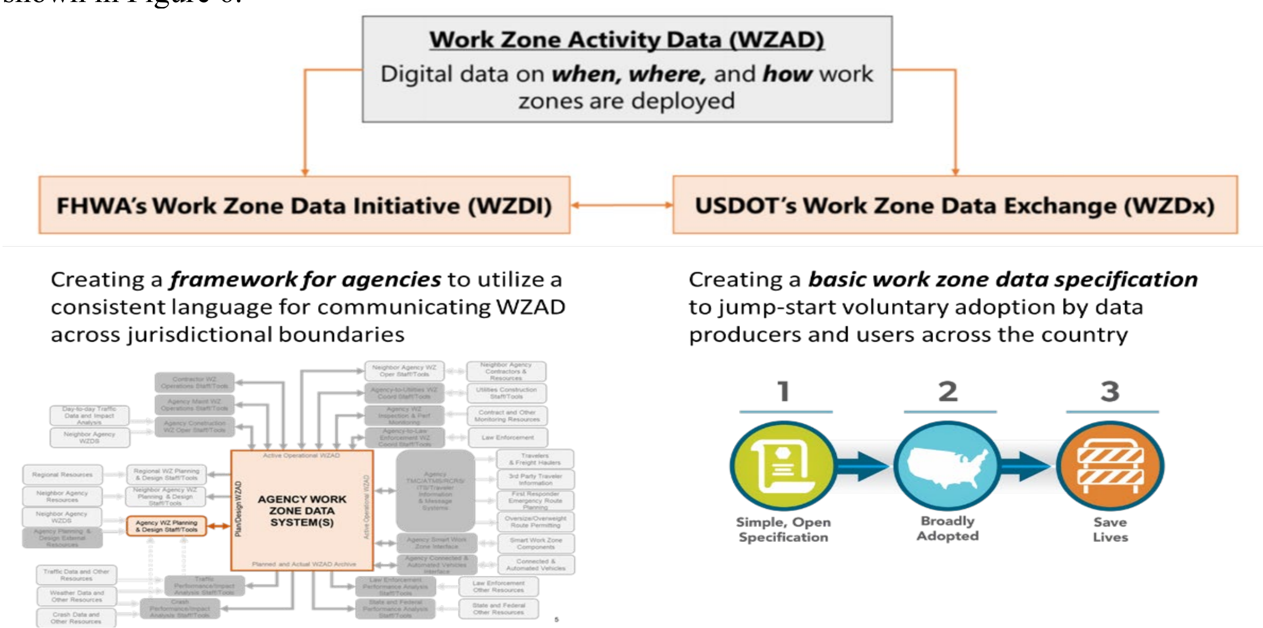
[10] "Data for Automated Vehicle Integration (DAVI)," U.S. Department of Transportation, accessed May 11, 2020, https://www.transportation.gov/av/data.

Work Zone Data Exchange and Initiative

Up-to-date information about dynamic road conditions, such as construction events, can help ADS and humans navigate safely and efficiently. Many IOOs maintain data on work zone activity. However, a lack of common data standards and convening mechanisms makes it difficult and costly for third parties—including original equipment manufacturers (OEM) and navigation applications—to access and use these data across various jurisdictions.

The purpose of FHWA's WZDI is to develop a recommended practice for managing WZAD and to create a consistent language, through the development of a data dictionary and supporting implementation documents, for communicating work zone activity information across jurisdictional and organizational boundaries. The effort promotes a stakeholder- and systems-driven perspective for WZAD that serves the emerging need for improved real-time road condition information as well as traditional operations management, which benefits from improved data portability throughout project life cycles. This initiative seeks a shared approach to managing WZAD to benefit the broad spectrum of potential uses and users, acknowledging ADS as one of the key use categories.

Implementation of this language is occurring through the USDOT Intelligent Transportation System Joint Program Office's (ITS–JPO) WZDx. The WZDx is a publicly available basic work zone data specification intended to jump-start voluntary adoption of a common data language by data producers and users across the country. By using WZDI guidance to determine agency-specific needs and uses for work zone data, and subsequently developing a customized specification using the WZDx as a foundation, there can be standardization for data sharing across organizational and geographical boundaries. The relationship between the two efforts is shown in Figure 6.



Source: Colorado Department of Transportation.

[11]

---

[11] https://www.transportation.gov/av/data/wzdx

The WZDx specification[12] enables IOOs to make harmonized work zone data available for third-party use. The intent is to make travel on public roads safer and more efficient through ubiquitous access to work zone activity data. Specifically, the project aims to get data on work zones into vehicles to help ADS and human drivers navigate more safely.

The WZDx working group is working to describe a set of common core data concepts, meanings, and enumerations to standardize a data feed specification to be used to publish work zone information. Common core is defined in this context as data elements needed for most (if not all) work zone data use cases that could possibly be defined. The data specification includes data elements that data producers (i.e., State transportation agencies and other IOOs) are already producing (required) as well as those not currently produced (optional). This common core is also considered extensible, meaning both required and optional data elements can be added to support specific use cases now and in the future.

The WZDx data feed will be incrementally enhanced to evolve into a data feed that supports advanced warnings to AVs in and around work zones. The current version (WZDx v1.1) is a first step in this effort and highlights common core elements that serve as a foundation for required data for effective data exchange. This version addresses data currently supported by existing data feeds published by public and private sector organizations.

WZDx data producers will use the specification to make their active work zone data feeds available to non-government users. These users will then use the harmonized data in a meaningful way, which will result in establishing the voluntary date exchange of work zone data. This approach is intended to be repeatable, leading to accelerated harmonization of local data.

[12] https://github.com/usdot-jpo-ode/jpo-wzdx/blob/master/README.md.

CHAPTER 3. TRAFFIC LAWS AND REGULATIONS

This chapter provides an overview of traffic laws and regulations and identifies existing traffic laws and traffic regulation databases, if any, or current forms and inventory of traffic regulation data.

OVERVIEW

For constitutional and historical reasons, traffic regulations in the United States are enacted and administered by the States rather than the Federal government. The first statewide traffic regulations were enacted in Connecticut in 1901,[13] before automobiles were common on roadways. Other States enacted their own regulations as need and custom dictated. The first version of the Uniform Vehicle Code (UVC) appeared in 1926.[14] The first Manual on Uniform Traffic Control Devices (MUTCD) was compiled by the American Association of State Highway Officials (AASHTO) in 1935.[15] The U.S. Department of Transportation (USDOT) was not established until 1966.

Although not directly responsible for traffic regulation, USDOT nonetheless oversees the safety of the nation's roadways. As described in , Title 23 of the United States Code , the Secretary of USDOT "Is authorized and directed to assist and cooperate with other Federal departments and agencies, State and local governments, private industry, and other interested parties, to increase highway safety."[16] This authority is then exercised through the department's review and approval of the States' highway safety programs. The National Highway Transportation Safety Administration (NHTSA) and the Federal Highway Administration (FHWA) Office of Safety administer highway safety programs within USDOT.

Most aspects of the national body of traffic regulations are consistent as a result of historical practices, institutional collaborations, and modern Federal oversight. The UVC[17] represents a working consensus, though it has no formal standing as a body of law and has not been updated since 2000. As a starting point for this analysis, however, the UVC provides a common reference for the definition of terms used in framing traffic regulations and the user categories to which the regulations apply. The structure of UVC, shown in table 1, has also been echoed in many of the States' traffic codes, forming a *de facto* standard for indexing of the regulations. Similarly, the UVC and State traffic codes generally point to the MUTCD, or the State's version, for the definition of particular traffic controls with which drivers are to comply.

---

[13] State of Connecticut, "An Act Regulating the Speed of Motor Vehicles," in *Public Acts Passed by the General Assembly of the State of Connecticut, in the Year 1901*, Chapter 69.

[14] J. Allen Davis, *The California Vehicle Code and the Uniform Vehicle Code*, 14 Hastings L.J. 377 (1963). Available at: https://repository.uchastings.edu/hastings_law_journal/vol14/iss4/3.

[15] "The Evolution of MUTCD," The Evolution of MUTCD - Knowledge - FHWA MUTCD, accessed May 11, 2020, https://mutcd.fhwa.dot.gov/kno-history.htm.

[16] 23 U.S.C. § 401.

[17] National Committee on Uniform Traffic Laws and Ordinances, *Uniform Vehicle Code* (Alexandria, Va: National Committee on Uniform Traffic Laws and Ordinances, 2000).

Table 1. Structure of the Uniform Vehicle Code.

Chapter	Title
1	Words and Phrases Defined
2	Highway Safety Administration
3	Certificates of Title and Registration of Vehicles
4	Theft Laws
5	Dealers, Wreckers, and Rebuilders
6	Driver's Licenses
7	Vehicle Insurance and Financial Responsibility
8	Owners of for-Rent Vehicles
9	Civil Liability
10	Accidents and Accident Reports
11	Rules of the Road
12	Equipment of Vehicles
13	Inspection of Vehicles
14	Size, Weight, and Load
15	Respective Powers of State and Local Authorities
16	Parties and Procedure Upon Arrest
17	Post Conviction Remedies
18	Effect of and Short Title of Code

Source: Uniform Vehicle Code, 2000.

The advent of automated vehicles (AV) creates multiple challenges for traffic regulations. Much of the body of traffic safety regulation concerns licensure of vehicles and drivers, and not specifically their behaviors. In the broadest sense, however, AVs blur the distinction between driver and vehicle, since driving automation systems reside in the vehicle and depend on its sensors. Recent regulation of AVs views AVs as a hybrid of vehicles and drivers and is largely limited to their licensure for operation design domains (ODD) in particular jurisdictions under the presumption that existing regulations on driver behavior will remain applicable.

EXISTING TRAFFIC LAWS AND TRAFFIC REGULATION DATABASES

As noted earlier, the body of traffic laws across the United States varies from State to State and among local jurisdictions within those States. The UVC itself is not a normative source of traffic regulations. It was developed from the larger body of traffic laws being developed by state and local governments as a means of documenting common aspects of those sets of laws, and has become the common reference for uniformity of traffic codes. Reviewing existing traffic laws and traffic regulation databases, therefore, requires consideration of a compilation of, State, and local perspectives.

Compilation Perspective

Since there are no national statutes requiring conformance to a single standard, and consequently no normative statutes, there have been various other efforts to document the actual diversity of traffic laws across the country. Particular perspectives and use cases for the resulting traffic regulation compilation or database have driven each effort.

Justia provides a seemingly complete compilation of laws, codes, and statutes at the Federal and State levels, implicitly including traffic regulations. It appears to have been built as a portal for linking individual legal research to legal counsel. It does not address local government codes. It is primarily a set of links to documents in portable document format (PDF) and Hypertext Markup Language (HTML) format. For example: https://law.justia.com/codes/kansas/2018/chapter-8/article-15/.[18]

The American Automobile Association (AAA) *Digest of Motor Laws*[19] provides summaries of traffic laws within individual States and across the country. It categorizes traffic laws, largely along the outline of the UVC, to list summaries of relevant laws across the nation. It also provides the same summaries for all categories within a particular State. It is not a complete representation of the traffic codes and does not link to the text of the actual statutes and codes. It does not address local variability within States.

The National Council of State Legislatures (NCSL) maintains a database of current legislation relating to traffic safety. It provides a view of the delineation of existing laws, the impacts of emerging technologies, and changes in public policy. It links to, but does not directly provide, the underlying and enacted bodies of traffic regulations. For additional resources, visit the following websites:

- NCSL Traffic Safety State Bill Tracking.[20]
- NCSL State Legislative Websites Directory.[21]

NCSL also provides a database of legislation directly related to AVs. For more information, visit the NCSL Autonomous Vehicles, Self-Driving Vehicles Enacted Legislation website.[22]

---

[18] "2018 Kansas Statutes :: Chapter 8 AUTOMOBILES AND OTHER VEHICLES :: Article 15 UNIFORM ACT REGULATING TRAFFIC; RULES OF THE ROAD," Justia Law, accessed May 12, 2020, https://law.justia.com/codes/kansas/2018/chapter-8/article-15/.

[19] "Digest of Motor Laws," AAA Digest of Motor Laws, accessed May 12, 2020, https://drivinglaws.aaa.com/.

[20] Ann Kitch and Gretchenn DuBois, Traffic Safety State Bill Tracking, accessed May 12, 2020, http://www.ncsl.org/research/transportation/state-traffic-safety-legislation-database.aspx.

[21] Administration, State Legislative Websites Directory, accessed May 12, 2020, https://www.ncsl.org/aboutus/ncslservice/state-legislative-websites-directory.aspx.

[22] Douglas Shinkle and Gretchenn Dubois, "Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation," Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation, accessed May 12, 2020, http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx.

The National District Attorneys Association (NDAA) maintains a National Traffic Laws Center to provide support to district attorneys in enforcement of traffic law. It does not specifically provide a database of laws.

Visit the National Traffic Law Center, for more information.[23]

The FindLaw website operated by Thomson Reuters provides summaries and links for some State traffic laws. It appears to be intended for individual research on traffic law enforcement and penalties for traffic law violations. It does not specifically provide a database of laws.

For more resources, visit the FindLaw website.[24]

The American Road and Transportation Builders Association (ARTBA) maintains a National Work Zone Safety Information Clearinghouse[25] of links to work zone safety laws across States and territories. In many cases it provides direct links to State laws, but notes in a disclaimer at the bottom of the web page, it is for information only and does not necessarily include all relevant statutes.

Visit https://www.workzonesafety.org/data-resources/laws-regulations-and-standards/state-work-zone-laws/.[26]

State Perspectives

State vehicle and traffic regulations are in all cases within the authority of the State legislatures. Execution and enforcement of those laws reside with the State motor vehicle administration, transportation, and police/patrol agencies, which may be separate or combined in various ways. Publishing the enacted vehicle and traffic statutes is a legislative function. State transportation agencies are as much users of those statutes as drivers within those States.

Although traffic laws across the United States are largely consistent and, in many cases, based on the UVC, available publications and databases of State traffic laws vary in structure, format, and wording. As described in the previous section, and shown in Table 2, electronic access to State traffic laws ranges from PDFs of entire sections of the statutes to searchable records of individual statutes.

The MUTCD provides another layer of consistency in traffic control deployments that complements the influence of the UVC. The State traffic codes prescribe that the State must have a standard for uniform traffic control and that drivers must obey the instructions of any official traffic control device. FHWA maintains an informational web page on the status of the States'

[23] "National Traffic Law Center," National District Attorneys Association, January 30, 2020, https://ndaa.org/programs/ntlc/.

[24] "State Traffic Laws," Findlaw, accessed May 12, 2020, https://traffic.findlaw.com/traffic-tickets/state-traffic-laws.html.

[25] "State Work Zone Laws," The National Work Zone Safety Information Clearinghouse, October 25, 2019, https://www.workzonesafety.org/data-resources/laws-regulations-and-standards/state-work-zone-laws/.

[26] Ibid.

traffic control device specifications at
https://mutcd.fhwa.dot.gov/resources/state_info/index.htm.[27]

Some States may provide detail beyond the State traffic code with databases of information on deployed traffic control. For example, Ohio provides records of permits to local agencies for traffic controls such as speed zones, traffic signals, and signs on State routes.[28] However, no national databases of traffic control deployments exist.

[27] "MUTCDs & Traffic Control Devices Information by State," Information by State - FHWA MUTCD, accessed May 12, 2020, https://mutcd.fhwa.dot.gov/resources/state_info/index.htm.

[28] https://www.transportation.ohio.gov/wps/portal/gov/odot/programs/traffic-regulations/traffic-regulations#page=1, accessed 12/31/2019.

Table 2. State traffic regulations.

State	Traffic laws link	Format	Search	Data elements	Download
AK	http://www.akleg.gov/basis/aac.asp#13%20part%201[29]	HTML	yes	section, text	no
AL	http://alisondb.legislature.state.al.us/alison/CodeOfAlabama/1975/Coatoc.htm[30]	HTML	no	section, text	no
AR	https://www.ardot.gov/divisions/legal/2015-motor-vehicle-and-traffic-laws-and-state-highway-commission-regulations-act-300/ /[31]	HTML	yes	section, text	no
AZ	https://www.azleg.gov/arsDetail/?title=28[32]	HTML	no	section, text	yes
CA	http://leginfo.legislature.ca.gov/faces/codesTOCSelected.xhtml?tocCode=VEH&tocTitle=+Vehicle+Code+-+VEH[33]	HTML	yes, by section	section, text	no
CO	https://leg.colorado.gov/laws[34]	HTML	yes	section, text	no
CT	https://www.cga.ct.gov/current/pub/chap_249.htm[35]	HTML	no	text	no
DC	https://code.dccouncil.us/dc/council/code/titles/50/chapters/22/[36]	HTML	no	section, text	no
DE	https://delcode.delaware.gov/index.shtml[37]	HTML, PDF	no	section, text	yes

[29] Alaska Admin Code, accessed May 12, 2020, http://www.akleg.gov/basis/aac.asp.

[30] Alabama Legislature, accessed May 12, 2020, http://alisondb.legislature.state.al.us/alison/CodeOfAlabama/1975/Coatoc.htm.

[31] "Arkansas Code Search: Laws and Statutes," Arkansas.gov, accessed May 12, 2020, https://www.ardot.gov/divisions/legal/2015-motor-vehicle-and-traffic-laws-and-state-highway-commission-regulations-act-300/.

[32] "Arizona Legislature," Arizona Legislature, accessed May 12, 2020, https://www.azleg.gov/arsDetail/?title=28.

[33] "VEH," Codes: Codes Tree - Vehicle Code - VEH, accessed May 12, 2020, http://leginfo.legislature.ca.gov/faces/codesTOCSelected.xhtml?tocCode=VEH.

[34] "Laws," Laws | Colorado General Assembly, accessed May 12, 2020, https://leg.colorado.gov/laws.

[35] Chapter 249 - Traffic Control and Highway Safety, accessed May 12, 2020, https://www.cga.ct.gov/current/pub/chap_249.htm.

[36] "Code of the District of Columbia," D.C. Law Library - Chapter 22. Regulation of Traffic., accessed May 12, 2020, https://code.dccouncil.us/dc/council/code/titles/50/chapters/22/.

[37] "State of Delaware - Search and Services/Information," State of Delaware - Delaware Code Online, accessed May 12, 2020, https://delcode.delaware.gov/index.shtml.

State	Traffic laws link	Format	Search	Data elements	Download
FL	http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=0300-0399/0316/0316ContentsIndex.html&StatuteYear=2019&Title=%2D%3E2019%2D%3EChapter%20316[38]	HTML		section, text	no
GA	https://dps.georgia.gov/ask-us/resources/georgia-traffic-codes[39]	HTML	yes	section, text	no
HI	https://www.capitol.hawaii.gov/leginfo.aspx[40]	HTML	yes	section, text	no
IA	https://www.legis.iowa.gov/law/iowaCode/sections?codeChapter=321&year=2020[41]	HTML, PDF, RTF		section, text	yes
ID	https://legislature.idaho.gov/statutesrules/idstat/Title49/[42]	HTML, PDF	no	section, text	yes
IL	http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1815&ChapterID=49[43]	HTML	yes	section, text	no
IN	http://iga.in.gov/legislative/laws/2019/ic/titles/009#9-21[44]	HTML	yes	section, text	no
KS	http://www.kslegislature.org/li/b2019_20/statute/008_000_0000_chapter/008_014_0000_article/008_014_0001_section/008_014_0001_k/[45]	HTML, PDF	yes	section, text	yes

[38] Statutes & Constitution :View Statutes : Online Sunshine, May 12, 2020, http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute.

[39] "Georgia Traffic Codes," Georgia Department of Public Safety, accessed May 12, 2020, https://dps.georgia.gov/ask-us/resources/georgia-traffic-codes.

[40] "Hawaii State Legislature," Legislative Information, accessed May 12, 2020, https://www.capitol.hawaii.gov/leginfo.aspx.

[41] Iowa Legislative Services Agency, Iowa Legislature - Code Section Listings, accessed May 12, 2020, https://www.legis.iowa.gov/law/iowaCode/sections?codeChapter=321.

[42] "Idaho Legislature," Idaho State Legislature, accessed May 12, 2020, https://legislature.idaho.gov/statutesrules/idstat/Title49/.

[43] "Illinois Compiled Statutes," Illinois General Assembly, accessed May 12, 2020, http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1815.

[44] Indiana General Assembly, "Indiana General Assembly," Indiana Code 2019 - Indiana General Assembly, 2020 Session, accessed May 12, 2020, http://iga.in.gov/legislative/laws/2019/ic/titles/009.

[45] "Legislative Resources," Statute | Kansas State Legislature, accessed May 12, 2020, http://www.kslegislature.org/li/b2019_20/statute/008_000_0000_chapter/008_014_0000_article/008_014_0001_section/008_014_0001_k/.

State	Traffic laws link	Format	Search	Data elements	Download
KY	https://apps.legislature.ky.gov/law/statutes/chapter.aspx?id=38038[46]	HTML, PDF	no	section, text	yes
LA	http://legis.la.gov/Legis/Laws_Toc.aspx?folder=75&level=Parent[47]	HTML	yes	section, text	no
MA	https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter89[48]	HTML	yes	section, text	no
MD	http://mgaleg.maryland.gov/mgawebsite/Laws/Statutes[49]	HTML	yes	section, text	no
ME	http://www.mainelegislature.org/legis/statutes/29-A/title29-Ach0sec0.html[50]	HTML, PDF, Microsoft® Word	yes	section, text	yes
MI	http://www.legislature.mi.gov/(S(0bnyen55ae4usctp0mbgholn))/mileg.aspx?page=ChapterIndex[51]	HTML	yes	section, text	no
MN	https://www.revisor.mn.gov/statutes/cite/169[52]	HTML, PDF	yes	section, text	yes
MO	https://www.revisor.mo.gov/main/OneChapter.aspx?chapter=304[53]	HTML	yes	section, text	no

[46] "Kentucky General Assembly," Kentucky Revised Statutes - Chapter 189, accessed May 12, 2020, https://apps.legislature.ky.gov/law/statutes/chapter.aspx?id=38038.

[47] Louisiana State Legislature - Legislative Law - Table of Contents, accessed May 12, 2020, http://legis.la.gov/Legis/Laws_Toc.aspx?folder=75.

[48] 191st General Court of the Commonwealth of Massachusetts, "Chapter 89: Law of the Road," Chapter 89, accessed May 12, 2020, https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter89.

[49] Maryland General Assembly, Laws - Statutes, accessed May 12, 2020, http://mgaleg.maryland.gov/mgawebsite/Laws/Statutes.

[50] Maine Legislature, "Title 29-A: MOTOR VEHICLES AND TRAFFIC," Maine Reivsed Statures, accessed May 12, 2020, http://www.mainelegislature.org/legis/statutes/29-A/title29-Ach0sec0.html.

[51] "Michigan Legislature," Michigan Legislature - MCL Chapter Index, accessed May 12, 2020, http://www.legislature.mi.gov/(S(boo5wj4iswrro4kpmd4bgqbu))/mileg.aspx?page=ChapterIndex.

[52] "Office of the Revisor of Statutes," Ch. 169 MN Statutes, accessed May 12, 2020, https://www.revisor.mn.gov/statutes/cite/169.

[53] Missouri Revisor of Statutes - Revised Statutes of Missouri, RSMo Chapter 304, accessed May 12, 2020, https://www.revisor.mo.gov/main/OneChapter.aspx?chapter=304.

State	Traffic laws link	Format	Search	Data elements	Download
MS	https://www.dfa.ms.gov/applications/ms-code/[54]	HTML	yes	section, text	no
MT	https://leg.mt.gov/bills/mca/title_0610/chapter_0080/parts_index.html[55]	HTML	yes	section, text	no
NC	https://www.ncleg.gov/Laws/GeneralStatuteSections/Chapter136[56]	HTML	yes	section, text	yes
ND	https://www.legis.nd.gov/cencode/t39.HTML[57]	HTML, PDF	no	section, text	yes
NE	https://www.nebraskalegislature.gov/laws/browse-chapters.php?chapter=60[58]	HTML, PDF	no	section, text	yes
NH	http://www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-XXI-265.htm[59]	HTML	no	section, text	no
NJ	https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu[60]	HTML	no	section, text	no

[54] State of Mississippi, "Government," Government | MS.GOV, accessed May 12, 2020, https://www.dfa.ms.gov/applications/ms-code/

[55] "Montana Code Annotated 2019," CHAPTER 8. TRAFFIC REGULATION - Table of Contents, Title 61, MCA, accessed May 12, 2020, https://leg.mt.gov/bills/mca/title_0610/chapter_0080/parts_index.html.

[56] North Carolina General Assemby, "Chapter 136 - Transportation.," ncleg.gov, accessed May 12, 2020, https://www.ncleg.gov/Laws/GeneralStatuteSections/Chapter136.

[57] "North Dakota Legislative Branch," North Dakota Century Code, accessed May 12, 2020, https://www.legis.nd.gov/cencode/t39.html.

[58] Nebraska Legislature, "NEBRASKA LEGISLATURE," Nebraska Legislature - Revised Statutes Chapter 60, accessed May 12, 2020, https://www.nebraskalegislature.gov/laws/browse-chapters.php?chapter=60.

[59] "New Hampshire Statutes," New Hampshire Statutes - Table of Contents, accessed May 12, 2020, http://www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-XXI-265.htm.

[60] New Jersey Legislature, "N.J. Legislative Statutes," N.J. Legislative Statutes, accessed May 12, 2020, https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu.

State	Traffic laws link	Format	Search	Data elements	Download
NM	https://laws.nmonesource.com/w/nmos/Chapter-66-NMSA-1978#!fragment/zoupio-_Toc27474856/BQCwhgziBcwMYgK4DsDWszIQewE4BUBTADwBdoAvbRABwEtsBaAfX2zgCYB2AFl4A4ArADYAlABpk2UoQgBFRIVwBPaAHI14iITC4ECpao1adekAGU8pAEKqASgFEAMg4BqAQQByAYQfjSYABG0KTsoqJAA[61]	HTML	yes	section, text	no
NV	https://www.leg.state.nv.us/nrs/NRS-484.html[62]	HTML	no	section, text	no
NY	https://dmv.ny.gov/about-dmv/nys-vehicle-and-traffic-law-information[63]	HTML	no	section, text	no
OH	http://codes.ohio.gov/orc/45[64]	HTML, PDF	no	section, text	yes
OK	http://webserver1.lsb.state.ok.us/OK_Statutes/CompleteTitles/os47.rtf[65]	RTF	yes	section, text	yes
OR	https://www.oregonlegislature.gov/bills_laws/ors/ors811.html[66]	HTML	no	section, text	yes
PA	https://www.legis.state.pa.us/cfdocs/legis/LI/consCheck.cfm?txtType=HTM&ttl=75&div=0&chpt=33[67]	HTML	no	section, text	yes

[61] "Chapter 66 - Motor Vehicles," NMOneSource.com, accessed May 12, 2020, https://laws.nmonesource.com/w/nmos/Chapter-66-NMSA-1978.

[62] NRS: CHAPTER 484 - TRAFFIC LAWS, accessed May 12, 2020, https://www.leg.state.nv.us/nrs/NRS-484.html.

[63] Pam Barnhart, "NYS Vehicle and Traffic Law Information," New York DMV, October 31, 2017, https://dmv.ny.gov/about-dmv/nys-vehicle-and-traffic-law-information.

[64] "Title [45] XLV MOTOR VEHICLES - AERONAUTICS - WATERCRAFT," Lawriter - ORC - Title [45] XLV MOTOR VEHICLES - AERONAUTICS - WATERCRAFT, accessed May 12, 2020, http://codes.ohio.gov/orc/45.

[65] "Oklahoma Statutes Title 47. Motor Vehicles", Accessed May 12,2020, http://webserver1.lsb.state.ok.us/OK_Statutes/CompleteTitles/os47.rtf.

[66] "Chapter 811—Rules of the Road for Drivers," Oregon State Legislature, accessed May 12, 2020, https://www.oregonlegislature.gov/bills_laws/ors/ors811.html.

[67] Legislativate Data Processing Center, "Chapter 33 Rules of the Road in General," The official website for the Pennsylvania General Assembly., accessed May 12, 2020, https://www.legis.state.pa.us/cfdocs/legis/LI/consCheck.cfm?txtType=HTM&ttl=75&div=0&chpt=33.

State	Traffic laws link	Format	Search	Data elements	Download
PR	https://www.estado.pr.gov/en/laws-of-puerto-rico/[68]	TBD[69]	TBD	TBD	TBD
RI	http://webserver.rilin.state.ri.us/Statutes/TITLE31/INDEX.HTM[70]	HTML	no	section, text	no
SC	https://www.scstatehouse.gov/code/title56.php[71]	HTML, Word	no	section, text	yes
SD	http://sdlegislature.gov/Statutes/Codified_Laws/DisplayStatute.aspx?Type=Statute&Statute=32[72]	HTML	yes	section, text	no
TN	https://www.tn.gov/lawsandpolicies.html[73]	HTML	yes	section, text	no
TX	https://statutes.capitol.texas.gov/[74]	HTML, PDF, Word	yes	section, text	yes
UT	https://le.utah.gov/xcode/Title41/Chapter6A/41-6a.html[75]	HTML, PDF, RTF, XML	yes	section, text	yes
VA	https://law.lis.virginia.gov/vacode/title46.2/[76]	HTML, PDF	yes	section, text	yes
VT	https://legislature.vermont.gov/statutes/title/23[77]	HTML	no	section, text	no

[68] Gobierno do Puerto Rico Departamento de Estado, "Laws of Puerto Rico, accessed February 23, 2021, https://www.estado.pr.gov/en/laws-of-puerto-rico/.

[69] The format, search capabilities, data elements, and download access for the Puerto Rico website could not be determined on the date of access.

[70] "TITLE 31 Motor and Other Vehicles," Title 31 - Index of Chapters, accessed May 12, 2020, http://webserver.rilin.state.ri.us/Statutes/TITLE31/INDEX.HTM.

[71] Code of Laws Title 56 Motor Vehicles, accessed May 12, 2020, https://www.scstatehouse.gov/code/title56.php.

[72] South Dakota Legislative Research Council, "Title 32 Motor Vehicles," Codified Laws – South Dakota Legislature, accessed May 12, 2020, https://sdlegislature.gov/Statutes/Codified_Laws/DisplayStatute.aspx?Type=Statute&Statute=32.

[73] "Laws, Policies, and Guides," Tennessee State Government - TN.gov, accessed May 12, 2020, https://www.tn.gov/lawsandpolicies.html.

[74] "Texas Constitution and Statutes - Home," Texas Constitution and Statutes - Home, accessed May 12, 2020, https://statutes.capitol.texas.gov/.

[75] Utah Code Chapter 41-6a, accessed May 12, 2020, https://le.utah.gov/xcode/Title41/Chapter6A/41-6a.html.

[76] "Virginia Law," Code of Virginia - Title 46.2. Motor Vehicles, accessed May 12, 2020, https://law.lis.virginia.gov/vacode/title46.2/.

[77] "Motor Vehicles," State House Dome, accessed May 12, 2020, https://legislature.vermont.gov/statutes/title/23.

State	Traffic laws link	Format	Search	Data elements	Download
WA	https://app.leg.wa.gov/rcw/default.aspx?Cite=46[78]	HTML	yes	section, text	no
WI	http://docs.legis.wisconsin.gov/statutes/statutes/346[79]	HTML, PDF	no	section, text	yes
WV	http://code.wvlegislature.gov/17C/[80]	HTML, PDF, Word	yes	section, text	yes
WY	https://wyoleg.gov/statutes/compress/title31.pdf[81]	PDF	no	section, text	yes

HTML = Hypertext Markup Language. PDF = portable document format. RTF = rich text format. TBD = to be determined. XML = Extensible Markup Language.

[78] https://app.leg.wa.gov/rcw/default.aspx?Cite=46.

[79] Wisconsin Legislature: Chapter 346, accessed May 12, 2020, http://docs.legis.wisconsin.gov/statutes/statutes/346.

[80] "West Virginia Code 17C," West Virginia Code, accessed May 12, 2020, http://code.wvlegislature.gov/17C/.

[81] State of Wyoming Legislature, "Title 31 – Motor Vehicles," accessed May 12, 2020, https://wyoleg.gov/statutes/compress/title31.pdf.

Local Perspectives

Vehicle and traffic laws may be subject to additional local regulation where allowed (or not disallowed) by State authority. These local authorities may include counties, parishes, cities, villages, townships, or other such entities as identified in the respective states. The number and diversity of such local authorities and their transportation agencies preclude cataloging their traffic regulations databases for this analysis, other than anecdotally.

In general, the local regulations reference the State laws with which the local law conform. Where allowed, local regulations may modify or take exception to the State traffic regulations. The City of Overland Park, Kansas, for example, provides its municipal code online at http://online.encodeplus.com/regs/overlandpark-ks/index.aspx.[82] The code is searchable by keyword or browsable by section. Title 12 of that code contains traffic regulations. Exceptions to the State code would generally be described as such. For example, Section 12.04.011 states, "All traffic control devices shall conform to the manual and specifications as adopted by the State department of transportation *with the exception of handicapped parking signs* as defined in 12.04.087" [italics added for emphasis]. Extensions to the referenced State regulations may not be noted as such. For example, in its traffic control signal legend, Overland Park includes a flashing yellow arrow indication, even though such an indication is not part of the code for the State of Kansas.

[82] "Municipal Code," Municipal Code, accessed May 12, 2020, http://online.encodeplus.com/regs/overlandpark-ks/index.aspx.

CHAPTER 4. UNIFORM VEHICLE CODE

This chapter details Uniform Vehicle Code (UVC) chapter 11 and variations and inconsistencies among different States and jurisdictions.

INTRODUCTION OF UNIFORM VEHICLE CODE CHAPTER 11

The rules of the road are under the authority of State legislatures to enact, which makes them difficult to enforce uniformly across all States. The UVC was a publication developed by the National Committee on Uniform Traffic Laws and Ordinances (NCUTLO). It was designed to provide a comprehensive guide of traffic and vehicle codes for States to use as they develop motor vehicle and traffic laws.[83] The UVC was last updated in 2000.[84]

UVC chapter 11 addresses traffic laws and is relevant to automated driving system (ADS) operational behavior and traffic regulation. Table 3 lists the areas of guidance from chapter 11.

Table 3. Uniform Vehicle Code chapter 11 sections.

Article I	Obedience to and Effect of Traffic Laws
Article II	Traffic Control Devices
Article III	Driving on Right Side of Roadway – Overtaking and Passing – Use of Roadway
Article IV	Right of Way
Article V	Pedestrians' Rights and Duties
Article VI	Turning and Starting and Signals on Stopping and Turning
Article VII	Special Stops Required
Article VIII	Speed Restrictions
Article IX	DUI and Other Serious Traffic Offenses
Article X	Stopping, Standing, and Parking
Article XI	Miscellaneous Rules
Article XII	Operation of Bicycles, Other Human-Powered Vehicles, and Mopeds
Article XIII	Special Rules for Motorcycles
Article XIV	Streetcars
Article XV	Victims of Traffic-Related Offenses
Article XVI	"Safe Streets Act" – Vehicle Immobilization Resulting from Continuing to Drive When the Driver's License Is Suspended or Revoked for DWI or DUI

DUI = driving under the influence. DWI = driving while intoxicated.

Source: Uniform Vehicle Code, 2000.

[83] https://mutcd.fhwa.dot.gov/ser-pubs.htm.

[84] Uniform Vehicle Code (2000), available at http://iamtraffic.org/wp-content/uploads/2013/01/UVC2000.pdf.

Not all of chapter 11 articles and recommended rules will apply to ADS, such as Article XV, Victims of Traffic-Related Offenses.

The UVC has not been updated since 2000. In 2015, draft updates were proposed, but no additional efforts have been made to keep the UVC up to date. Most States have already adopted their traffic laws and the Internet has made individual laws more easily accessible to the public and to other State legislatures.

VARIATIONS IN TRAFFIC RULES AMONG STATES AND TERRITORIES

The UVC was developed by members who represented many State governments and related organizations. As a result, the guidance codes the UVC contains are similar to the final rules that most States have adopted. However, there are some variations in traffic rules among States.

For decades, the American Automobile Association (AAA) has reviewed and summarized the different motor vehicle laws across the United States and Canada. The AAA *Digest of Motor Laws*[85] is a searchable online database of these laws and rules on driving and owning a motor vehicle (including traffic laws, vehicle titling and registration requirements, fees and taxes, driver's licenses, and traffic safety).

For some traffic safety laws—for example, impaired driving—there is not much variation among States. According to the *Digest of Motor Laws*, "All 50 states and the District of Columbia have impaired driving laws that prohibit the operation of a motor vehicle while under the influence of intoxicating beverages, with the illegal per se limit set at 0.08 percent blood alcohol content (.08 BAC). All 50 states and the District of Columbia set the legal drinking age at 21."[86] Even with a traffic safety law that is similar among all States, such as impaired driving, there are still differences between States on the use of ignition interlocks for impaired drivers.

The differences for other traffic safety laws vary from State to State, which would require an ADS to learn the rules of each State. For example, Figure 7 illustrates the differences, by State, for hazard light use, which range from being permitted while driving to not permitted while driving or with exceptions. In this case, ADS must be aware of which State it is operating in and adjust its operational behavior accordingly.

---

[85] "Home - AAA Digest of Motor Laws," accessed May 12, 2020, https://drivinglaws.aaa.com/.

[86] "Impaired Driving," AAA Digest of Motor Laws, accessed May 12, 2020, https://drivinglaws.aaa.com/tag/impaired-driving/.

Graphic created by Kittelson & Associates, Inc. based on the *AAA Digest of Motor Laws.*[87]

Figure 7. Illustration. Comparison of hazard light use regulations by State.

Following distance is another traffic safety law that varies by State. The UVC guidance is, "Do not follow another vehicle more closely than is reasonable and prudent" (Article III: Driving on the Right Side of Roadway – Overtaking and Passing – Use of Roadway).[88] New York State recommends using a "two-second rule" to allow space to stop.[89] California recommends using a "three-second rule" to avoid tailgating.[90] Florida[91] and Pennsylvania[92] instruct drivers to keep a

---

[87] "Hazard Light Use", *AAA Digest of Motor Laws*, accessed May 19, 2020, https://drivinglaws.aaa.com/tag/hazard-light-use/.

[88] National Committee on Uniform Traffic Laws and Ordinances (NCUTLO), 2000. *Uniform Vehicle Code*. § 11-310—Following too closely, pg. 134. Accessed on May 20, 2020. http://iamtraffic.org/wp-content/uploads/2013/01/UVC2000.pdf.

[89] New York Department of Motor Vehicles, 2018. *Driver's Manual*. "Allow Yourself Space", pg. 45. Accessed on May 20, 2020. https://dmv.ny.gov/brochure/mv21.pdf

[90] California Department of Motor Vehicles, 2020. *California Driver Handbook*, English Version, pg. 43, 67. Accessed on May 20, 2020. https://www.dmv.ca.gov/web/eng_pdf/dl600.pdf.

[91] Florida Highway Safety and Motor Vehicles, 2018. *Official Florida Driver License Handbook*, pg. 32. Accessed on May 20, 2020. https://driving-tests.org/florida/fl-dmv-drivers-handbook-manual/.

[92] Pennsylvania Department of Transportation, 2020. *Pennsylvania Driver's Manual*. PUB 95 (3-19) English Version, pg. 35. Accessed on May 20, 2020. https://www.dot.state.pa.us/Public/DVSPubsForms/BDL/BDL%20Manuals/Manuals/PA%20Drivers%20Manual%20By%20Chapter/English/PUB%2095.pdf.

minimum 4-second following distance. Florida has a separate following-distance requirement of 300 feet for trucks or any vehicle towing another vehicle.[93]

Headlight use requirements also vary by State. Most States require headlight use between sunset and sunrise, with some States requiring use only one-half hour after sunset to one-half hour before sunrise. For example, some States also specify that headlights should be used when visibility is less than 500 feet, while some specify less than 1,000 feet. Some States also specify that headlights must be used whenever windshield wipers are turned on.

Variations in Dynamic or Local Traffic Laws

Time-of-day speed limits are regulatory, such as in construction work zones or when children are present near a school. They are predictable, which makes them less dynamic than truly traffic-dependent speed limits.

Dynamic, traffic-dependent regulations may vary by State. At least 15 States use variable speed limits (VSL).[94] These VSLs may be regulatory (enforceable) or advisory (but still subject to the fundamental speed rule) depending on the State. For example, Wyoming's VSL law is regulatory (strictly enforced).[95] Washington State allows local authorities to establish or alter maximum speed limits, stating that "Any altered limit established as hereinbefore authorized shall be effective when appropriate signs giving notice thereof are erected. Such maximum speed limit may be declared to be effective at all times or at such times as are indicated upon such signs; and differing limits may be established for different times of day, different types of vehicles, varying weather conditions, and other factors bearing on safe speeds, which shall be effective when posted upon appropriate fixed or variable signs."[96]

Dynamic congestion-based tolls are regulatory to the extent that the vehicle owner gets a ticket in the mail if the vehicle does not have a toll tag or the required number of people in the vehicle to avoid the toll or pay a reduced toll. In California, low emission vehicles and zero emission vehicles displaying a special-issued decal may use the high-occupancy vehicle (HOV) lanes, even if they do not have the required number of people in the car.[97] ADS may need to decide if the vehicle is eligible to use the express lane (i.e., has a toll tag, has the minimum number of occupants, or is otherwise eligible).

---

[93] Florida Highway Safety and Motor Vehicles, 2018. *Official Florida Driver License Handbook*, pg. 33. Accessed on May 20, 2020. https://driving-tests.org/florida/fl-dmv-drivers-handbook-manual/.

[94] https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2018/02/23/variable-speed-limits-improving-safety-or-confusing-motorists.

[95] http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Traffic%20data/2016%20Speed%20Limits%20booklet.pdf.

[96] RCW 46.61.415.5, available at https://app.leg.wa.gov/RCW/default.aspx?cite=46.61.415.

[97] California Department of Motor Vehicles, 2020. *California Driver Handbook*, English Version, pg. 48. Accessed on May 20, 2020. https://www.dmv.ca.gov/web/eng_pdf/dl600.pdf.

Examples of other dynamic regulations that may vary by day of week, time of day, or road or weather conditions include:

- Using wipers when it rains.
- No parking on the street on certain days during overnight street-sweeping hours.
- Curb parking lane opened up to traffic during peak hours (typical in older downtowns).
- Obeying police officers directing traffic.
- Pulling over and stopping when ambulances, fire trucks, or police sound their sirens.
- Not crossing a flooded wash (Arizona law for dealing with flash floods).[98]
- Stopping when a school bus stops and flashes its red lights.
- Daytime versus nighttime freeway speed limits.
- Chains required to go over a summit during winter snowstorms.
- Lower speed limit when chain controls are in place.

Local authorities may also assign traffic laws that differ from the State laws. In New York State, a right turn on red is permitted at signalized intersections unless there is a no-turn-on-red sign posted. However, New York City does not permit a right turn on red unless there is a sign that permits it.[99]

---

[98] Arizona Department of Transportation Motor Vehicle Division, 2019. *Arizona Driver License Manual and Customer Service Guide*, 99-0117 R04/2019, pg. 44, accessed on May 20, 2020, https://apps.azdot.gov/files/mvd/mvd-forms-lib/99-0117.pdf.

[99] https://dmv.ny.gov/about-dmv/chapter-4-traffic-control-2.

CHAPTER 5. ASSESSMENT AND SOLUTION

This chapter provides assessment of the current technical challenges of implementing traffic laws and regulations databases, identifies constraints and limitations, and recommends solutions from the perspective of design, deployment, and digital technology systems.

ASSESSMENT

It is possible to transform the guiding rules from the Uniform Vehicle Code (UVC) to requisites for automated driving system (ADS) behavior development. However, as explained above, many traffic rules vary by State and by the local authority. It will take a substantial effort to create a comprehensive database of State laws, even using existing compilations—for example, the American Automobile Association (AAA) *Digest of Motor Laws*—as a starting point.

New State Traffic Legislation

Currently, traffic laws are maintained and administered by the presiding jurisdiction. There is no sanctioned central repository for all traffic laws at all jurisdictional levels. The regulations database would need to support inclusion of all new traffic laws that go beyond UVC guidance. There will need to be some version/configuration control, such that it can be determined what version of traffic law is being provided to an ADS. There will need to be procedures to update the database as new legislation is enacted. Many States have adopted new traffic laws that were not necessarily relevant the last time the UVC was updated. For example, in 2019, Florida enacted Act 2019-44, Use of Wireless Communications Devices While Driving, which prohibits texting while driving and prohibits the use of handheld wireless communications devices in school crossings, school zones, or work zones. The law also makes these violations a primary offense. This requirement does not apply to a motor vehicle operator who is "Operating an autonomous vehicle, as defined in s. 316.003, in autonomous mode."[100]

Local Traffic Laws

The greatest limitation in creating and maintaining a comprehensive database of all traffic laws relates to local rules. Currently, there is no database that documents all local agency traffic laws. Most States require approval by only their State legislature or department of transportation (DOT) to change local traffic laws.

Automated Vehicle State Legislation

In addition to the variation of traffic laws by State, there is also variation and evolution in the autonomous vehicle enacted legislation or executive orders, as shown in Figure 8. The National Conference of State Legislatures (NCSL) regularly updates a database of these actions. Similar to the State traffic laws, the State automated vehicle (AV) legislation could be transformed into a

---

[100] 2019 FL H 107 enacted as Act No. 2019-44, available at http://laws.flrules.org/node/7818.

database of requisites for ADS behavior development. This would also take a substantial effort to create and would require routine monitoring to update the database as new legislation is enacted.

Source: National Conference of State Legislatures[101]

Figure 8. Illustration. States with enacted legislation and executive orders for autonomous vehicles.

As of the writing of this report, the original equipment manufacturer (OEM) is required to meet Federal Motor Vehicle Safety Standards (FMVSS), and the human driver must pass the State driver's license requirements and comply with the rules of the road to maintain a license.

HIGH-LEVEL NEEDS

This section discusses high-level design and deployment needs of the proposed traffic regulation databases. The needs for building digital technology systems are also discussed in terms of system platforms, testing technologies, cybersecurity, and data privacy.

[101] "Autonomous Vehicles – Self-Driving Vehicles Enacted Legislation". Accessed on May 19, 2020, https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx.

Design and Deployment

Regulation Data Model

Developing a data model for traffic regulations is essential, but will depend on potential user needs for validation. The model has to express the regulations in terms of settings and behaviors that AVs can perceive and act on for various roadway environments (e.g., work zones and adverse weather conditions). It will need to address both permissible vehicle behaviors and traffic controls and signs—for example, right turns permissible at a red traffic signal, except where signed as not permitted. It will need to address static and dynamic controls, whether by time of day (e.g., a school speed zone) or by local dynamic signal and signage (e.g., ramp metering signals or variable speed limits [VSL]). It will need to address cases where ADS has to depend on perception of physical markings and signage and where controls are provided by infrastructure-to-vehicle/vehicle-to-infrastructure (I2V/V2I) communications, as with a signal phase and timing (SPaT) message. And it will need to address incidents and work zones as well as normal operations.

Vehicle Function Regulations

Some traffic laws imply required vehicle equipment or functions. For example, some States require the use of windshield wipers when it rains, which implies that the vehicle must be equipped with wipers. This study assumes that the OEM responsible for the vehicle using the ADS will comply with FMVSS or exemption specifications for safety systems, equipment, and performance as NHTSA requires. However, FMVSS are being updated in response to ADS needsand OEMs will need to continue to track them as changes are made.

Regulations Data Access and Collection

As previously described, State traffic codes are readily available and generally able to be collected from the regulatory sources. Local government codes are unlikely to be so readily available and will present additional challenges for identification and collection. Data on regulatory traffic controls within a jurisdiction are significantly less available in database form, though generally observable in field deployments.

Data Format Limitations with Automated Driving System Behavior

Traffic codes are written for human interpretation and application and may face challenges in being adapted for ADS. This is an issue of identifying driving tasks and different roadway environments and scenarios in which the regulations apply, and specifying the operational limits associated with those tasks. For example, how would an ADS be expected to interpret "exercising due care" in avoiding pedestrians and other vulnerable users? Traffic controls are currently deployed as marked or signed indications along roadways. These controls provide data as images and words to be interpreted by human drivers as permitting or precluding specific driving behaviors. ADS will need to acquire the same information as controls derived from its own imaging systems, static controls associated with mapped locations, or static and dynamic control data provided in I2V exchanges. Some agencies may maintain sign or signal databases, but the mapped and dynamic control data are generally not currently available.

Coordination across Jurisdictions

Just as human drivers need to know the rules of the road in various jurisdictions through which they travel, ADS will need to be aware of its current location and the applicable regulations. In practice, much of the local variability will take the form of signed controls on the roadway. But there may still be a need for a higher level set of behavior principles—like no right turn on red—to be more generally encoded into the AV control algorithms.

Funding Issues

Obtaining and rendering traffic regulations into a database form are somewhat simplified by the general online availability of State traffic codes. There may be costs associated with the digest of the regulations into actionable ADS input. Costs of providing traffic control data to ADS are largely unknown at this point. Those costs will depend on yet-to-be-determined factors including the agency's own controls databases, availability of local high-definition maps, and the agency's intent for implementing dynamic controls to be provided over the air in real time.

Digital Technology Systems

Currently, the private industry has taken different approaches to addressing this issue. For example, in a speech at the Automated Vehicle Symposium 2019,[102] Chris Urmson, cofounder and chief executive officer (CEO) of Aurora, emphasized the criticality of accounting for variations in traffic regulations, which may have an impact on ADS behavior and safety. One solution he mentioned is to include the information in Aurora's high-definition maps developed for the on-road testing regions, and in some cases modified algorithms need to be implemented. Another solution, using a concept similar to this approach is a cloud-based database solution. The INRIX® Road Rules™ tool[103] is one such example that uses the SharedStreets open data format.[104] These kinds of tools, however, focus on points-of-interest data entry for the placement of control devices and other traffic related information such as signage, parking restrictions, and turn lanes. While it is a reductive task to create a Google Maps™ web mashup interface to manually enter municipal transportation features, the goal of this task is to explore ways to maximize automatic data sharing with regard to ADS mobility governance.

Which digital technology systems infrastructure owner-operators (IOO) may use to implement traffic regulation databases would depend on agency capability to address changing traffic environments, particularly considering that more traffic regulations can be dynamic in the future, and the proposed traffic regulation database will be closely tied to other components of dynamic traffic management (e.g., VSL systems). Emerging active demand and traffic management technologies and new data sources (e.g., those from connected and automated vehicles [CAV] and advanced perception and monitoring systems) are impacting agencies . They have realized the necessity of capacity building for fully leveraging the benefits of the new technologies and data sources. Agency capability in terms of technology systems is discussed from the following

---

[102] https://www.automatedvehiclessymposium.org/program.

[103] http://inrix.com/products/road-rules/.

[104] https://sharedstreets.io/.

three perspectives: system platforms, technology deployment and testing, and cybersecurity and data privacy.

System Platforms

The technology supporting big data and cloud scale systems continues to evolve, offering many choices to agencies. Historically, the primary technology choices for agencies have been hosting data and systems on-premise, in the cloud, across multiple clouds, or using a hybrid approach; other possible choices include computational platforms:

- Cloud environments: Cloud environments may provide subscription-based services, including infrastructure services such as computing power, networking, and security and storage, and provide software services, such as databases, business applications, Internet of Things, and machine learning.
- Premise environments: Premise environments (data centers) are owned and operated by the agency or through contract services. Premise environments typically operate in one or more managed data centers utilizing networking, hardware, and software services to run business applications.
- Computational platforms: Computational platforms are stacks of integrated software and hardware useful for high-volume calculation and analytics. These are typically deployed as high-performance computing systems integrated with advanced models providing analytic and research capabilities.

The ability to deploy and migrate systems and data across a variety of platforms allows agencies to build solutions based on business needs without the constraint of utilizing a single cloud vendor or technology stack.

Technology Testing

Technology testing is an integral part of the deployment of new technologies. Technology testing is the process of analyzing a system or a component by providing defined inputs and comparing them with the desired outputs. Testing can be divided into two categories: manual testing or automated testing.

Manual testing, as the name suggests, is done manually and requires human input, analysis, and evaluation. Automated testing is the automated version of manual testing; using automation in testing helps avoid human errors, which can occur due to human fatigue of performing repeated processes. Automated testing programs will not miss a test by mistake. The automated test program will also provide the means of storing the test results accurately. The results can be automatically fed into a database, which can be used to provide necessary statistics on how the new data system is performing. Automated testing can detect errors in the database, which may have a major impact on ADS traffic law compliance and affect ADS behavior and safety.

Objectives of automated testing are as follows:

- Perform repetitive/tedious tasks to accurately reproduce tests.
- Validate requirements and functionality at various levels.
- Simulate multiple users exercising system functionality.
- Execute more tests in a short amount of time.
- Reduce test team head count.

Cybersecurity and Data Privacy

For any advanced data system, many ownership and maintenance (O&M) considerations involve management and security of data. The Federal Highway Administration (FHWA) Reliability Data Guide's Data Ownership and Maintenance section[105] presents a sample list of fundamental considerations likely to govern O&M levels of effort and expense:

- Who will pay to collect, store, and share the data?
- Who (if anyone) can sell the data and to whom?
- What privacy issues in the data must be addressed?
- Who is allowed to access the data and what data are they permitted to access (e.g., all of the data, only a subset of the data)?
- For what purposes are the data allowed to be used (e.g., if collected for analysis purposes only, could they also be used for enforcement purposes)?

The Real-Time Data Capture and Management State of the Practice Assessment and Innovations Scan[106] addressed issues related to data capture, management, archiving, and sharing to encourage collaboration, research, and operational development and improvement. The scan documented the following best practices for access, security, and privacy:

- Generally, the holder of the data controls access to the data. Within the transportation and logistics community, this access is carefully controlled.
- Systems are in place that ensure data are accessed only by the intended people, and only to the degree those people need the data. Transportation and logistics industry data can be extremely sensitive, with disastrous consequences for a business if accessed by persons with malicious intentions.
- Usually, data access is password-protected. Because data generated within the logistics systems are often financial, they are strongly encrypted when sent. However, several applications can retrieve aircraft and vessel tracking data, often with other identifying

---

105 https://www.fhwa.dot.gov/goshrp2/Solutions/Reliability/L02_L05_L07_L08_C11/Reliability_Data_and_Analysis_Tools.

106 SAIC (2011), Real-Time Data Capture and Management State of the Practice Assessment and Innovations Scan: Lessons from Scan of Current Practices, Report prepared for the Federal Highway Administration.

information. The security clearance or password protection to access data through these applications is often minimal.

- The protection of data sources is extremely important. In the search engine industry, data sources are so heavily protected that there is not even disclosure of how, exactly, they are protected.

The scan documented the following best practices for data storage and backup:

- Frequent backups and off-site storage are typical.
- Preventative maintenance should be performed regularly.
- Careful consideration should be devoted to determining how much and for how long data should be stored. In aviation, for instance, data are kept for a relatively short time frame because the need is for real-time, rather than historical, information. At the same time, data can be available for revision if there is an incident to investigate.

The scan documented the following best practices for operations and maintenance:

- Deployment should begin on a reasonable scale, such as implementing in a small geographical area or using easily manageable data.
- Multiple servers should be used to distribute real-time loads. Several technologies enable this load distribution.
- It is important to consider determining the needed resolution or granularity of the data. This may vary depending on the context and use of the data.
- It is necessary to determine what is critical to communicate and what is not. For instance, railroad and airline alert systems only collect the necessary data that can alert an operator to a particular problem.

The scan documented the following best practice for critical failures:

- A common issue is that correcting a problem often depends on a single person, meaning that it depends on the person's availability. Therefore, it is important to have staff available around the clock to solve potentially catastrophic failures. The higher labor cost is a necessary expense if the system needs to be highly available at all times.

U.S. Department of Transportation
Federal Highway Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

October 2020

FHWA-HOP-20-013