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American Association of
Motor Vehicle Administrators

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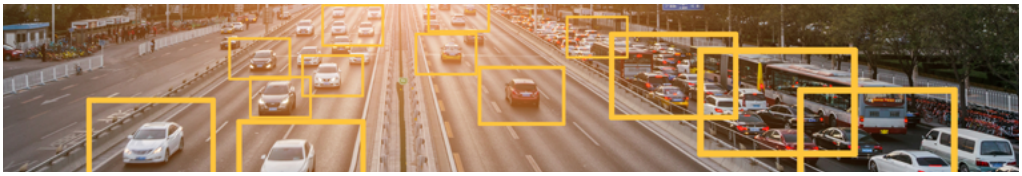
Driverless innovation
Automated
REVOLUTION
TRANSPORTATION
SYSTEM advances
TECHNOLOGY

Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles



May 2018

VEHICLE STANDING COMMITTEE
AUTONOMOUS VEHICLES BEST PRACTICES WORKING GROUP

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Executive Summary

The American Association of Motor Vehicle Administrators (AAMVA) is a tax-exempt, nonprofit organization developing model programs in motor vehicle administration, law enforcement, and highway safety. The association also serves as an information clearinghouse in these areas and acts as the international spokesperson for these interests. Founded in 1933, AAMVA represents the state and provincial officials in the United States and Canada who administer and enforce motor vehicle laws. AAMVA's programs encourage uniformity and reciprocity among the states and provinces. The association also serves as a liaison with other levels of government and the private sector. Its development and research activities provide guidelines for more effective public service. AAMVA's membership includes associations, organizations, and businesses that share an interest in the association's goals.

AAMVA recognized an opportunity to provide leadership and assistance to the motor vehicle administrative and law enforcement communities by establishing the Autonomous Vehicle Working Group (AVWG) to examine the potential impacts of highly automated vehicle (HAV) testing and deployment on these communities and to develop guidance.

HAVs are monitored by the automated driving system and do not need a human driver to operate but may require a human driver to take control of the vehicle. These vehicles consist of Levels 3 Conditional Driving Automation, 4 High Driving Automation, and 5 Full Driving Automation as established by the Society of Automotive Engineers (SAE) International and are outlined in Chapter 2. The recommendations in this report apply to these levels.

SAE, which devises consensus standards for the engineering industry, established a six-tier classification system ranging from no vehicle automation to full vehicle automation. Each vehicle is expected to be classified within the six levels according to the following:

- Level 0 – No Driving Automation
- Level 1 – Driver Assistance
- Level 2 – Partial Driving Automation
- Level 3 – Conditional Driving Automation
- Level 4 – High Driving Automation
- Level 5 – Full Driving Automation

The purpose of this report is to address how automated vehicle technology will directly impact vehicle registration and titling programs; driver training, testing, and licensing programs; enforcement of traffic laws; and first response to traffic related incidents. This report contains recommendations for jurisdictions that choose to regulate testing and deployment of HAVs. The recommendations are voluntary; jurisdictions are not required to adopt them.

The following provides a summary of the four major sections outlined in this report to address the safe testing and deployment of HAVs.

Administrative Considerations

This chapter addresses the administrative considerations for the safe testing and deployment of HAVs and includes the following section:

- Administration

Vehicle Credentialing Considerations

This chapter addresses how automated vehicle technology will directly impact vehicle registration, titling programs, license plates, financial responsibility, and safety standards and includes the following sections:

- Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways
- Vehicle Registration
- Titling and Branding for New and Aftermarket Highly Automated Vehicles
- License Plates
- Highly Automated Vehicle Information on the Manufacturer's Certificate of Origin and Manufacturer's Statement of Origin
- Financial Responsibility
- Federal Motor Vehicle Safety Standards (FMVSS) and Canadian Motor Vehicle Safety Standards (CMVSS)

Driver Licensing Considerations

This chapter addresses how automated vehicle technology will directly impact driver training, driver testing and licensing programs and includes the following sections:

- Driver and Passenger Roles Defined
- Driver License Requirements for Testing by Manufacturers and Other Entities
- Driver Training for Consumers of Deployed Vehicles
- HAV Driver Training for Motor Vehicle Agency Examiners, Driver Education Programs, and Private Instructors
- Driver License Skills Testing with Automated Vehicle Technologies
- Endorsements and Restrictions for Deployed Vehicles

Law Enforcement Considerations

This chapter addresses how automated vehicle technology will directly impact enforcement of traffic laws and first response to traffic related incidents and includes the following sections:

- Crash and Incident Reporting
- Criminal Activity
- Distracted Driving
- Enforcement of Permit Conditions
- Establishing Operational Responsibility and Law Enforcement Implications
- First Responder Safety
- Law Enforcement and First Responder Training
- Vehicle Response to Emergency Vehicles, Manual Traffic Controls, and Atypical Road Conditions
- System Misuse and Abuse
- Vehicle Identification
- Adherence to Traffic Laws

A summary of the specific recommendations for jurisdictions described in these four sections can be found on page 49, and the recommendations for manufacturers and other entities can be found on page 55.

Conclusion

A successful path to the safe testing and deployment of HAVs must include appropriate government oversight developed in coordination with strong stakeholder engagement formed through partnerships with the many entities engaged in or affected by these rapidly developing technologies. These partnerships should be formed to address the far-reaching impacts of the technologies and should include representatives from broad reaching government organizations, government support associations, industry, research institutes, and advocacy groups.

AAMVA will continue to work closely with and coordinate HAV initiatives through partnerships with the United States Department of Transportation (U.S. DOT) and the Canadian Council of Motor Transport Administrators (CCMTA). To keep this report relevant and to provide the best possible guidance to the AAMVA community, it is expected the AVWG will update this report periodically for the foreseeable future (see Chapter 7 Next Steps). The AVWG is committed to keeping pace with the evolution of vehicle technology, providing timely information, and sharing its expertise.

Chapter 1 Introduction

Automated and non-automated vehicles will share the roadway, creating challenges for the safe integration of HAVs. Motor vehicle and law enforcement agencies will need to adapt as technologies advance and HAVs begin to saturate the market.

In recent years, manufacturers and other technology companies began testing HAVs on public roadways, prompting the need for jurisdictions to explore ways to regulate this emerging technology to ensure safety of the motoring public. A few jurisdictions began to adopt regulations using different approaches, making it apparent that there was a need for a framework to support a consistent regulatory approach.

In addition, introduction of HAVs into the existing roadway transportation system requires a transformation many jurisdictions are not currently equipped to manage without assistance from industry, partners, and other community members.

The AVWG began its work in 2014 by making a significant contribution to the Model State Policy contained in Section II of the National Highway Traffic Safety Administration's (NHTSA) *Federal Automated Vehicles Policy*, published in September 2016 and NHTSA's *Automated Driving Systems: A Vision for Safety 2.0* published in September 2017. The working group also examined the potential impacts of HAV testing and deployment on jurisdictions and began developing this report, which provides voluntary recommended guidelines regarding motor vehicle administration and law enforcement for the safe testing and deployment of HAVs.

Jurisdictional implementation of the recommendations will facilitate a consistent regulatory framework that balances current public safety with the advancement of vehicle innovations, establishing the potential to reduce crashes, fatalities, injuries, and property damage.

Report Structure

The AVWG developed this report to provide voluntary recommended guidelines for motor vehicle administrations, law enforcement, manufacturers, and other entities for the safe testing and deployment of HAVs (outlined in Chapters 3 to 6 of this report). The recommended guidelines are divided into four major sections:

- Administrative Considerations;
- Vehicle Credentialing Considerations;
- Driver Licensing Considerations; and
- Law Enforcement Considerations.

The Appendices include:

- Appendix A, which provides a Summary of Recommended Jurisdictional Guidelines for the Safe Testing and Development of HAVs;
- Appendix B, which provides a Summary of Recommendations for Manufacturers and Other Entities (MOE) for the Safe Testing and Development of HAVs; and
- Appendix C, the AVWG roster.

Guiding Principles

The principles guiding the development of this report were:

- Facilitating a consistent and balanced oversight approach by motor vehicle administrators to avoid inconsistent regulatory practices that could create unnecessary hurdles for vehicle and technology manufacturers;
- Supporting the research and development of technology that has the potential to improve traffic safety while providing mobility options for underserved populations;
- Supporting the safe testing and deployment of HAVs; and
- Confirming the roles and responsibilities of jurisdictions and the federal government.

The recommendations in this report apply to Level 3, 4, and 5 noncommercial motor vehicles as established by SAE International[1] unless otherwise stated (see Out of Scope).

Collaboration Among Stakeholders and Partners

A successful path to the safe testing and deployment of HAVs must include developing strong partnerships. These partnerships should be formed to address the far-reaching impacts of the technologies and should include representatives from broad-reaching government organizations, government support associations, industry, research institutes, and advocacy groups.

Because automotive technology development and deployment has worldwide impact; collaboration within jurisdictions, nationally and internationally, is vital to the safe integration of HAVs. Several national efforts, in which AAMVA, AAMVA members, and the AVWG participated, helped form the development of this report. In addition, AAMVA and CCMTA continue to collaborate to provide consistent recommendations to U.S. and Canadian jurisdictions.

Current Regulatory Efforts

Some jurisdictions have developed requirements for manufacturers and other entities to test HAVs on public roadways; others have chosen not to adopt specific requirements until more information is available. Jurisdictional activities were reviewed in an effort to learn different oversight approaches. The AVWG used the collective experiences of the jurisdictions to assist in shaping these recommendations.

Out of Scope

The AVWG determined that several topics were out of scope. Although critical to the testing and deployment of HAVs, they are not addressed in this report. These include but are not limited to:

- commercial motor vehicles, as defined by the Federal Motor Carrier Safety Regulations (FMCSRs) (390.5),
- training for Motor Vehicle Agency (MVA) staff,
- jurisdictional safety inspection programs and criteria,
- import/export considerations,
- data privacy and security, including personal identifiable information (PII),
- cybersecurity,
- enabling infrastructure,
- economic considerations, and
- environmental impacts.

Some of these topics may be addressed in future versions of this report as discussed in Chapter 7, "Next Steps."

1 SAE International's Surface Vehicle Recommended Practice: Taxonomy and Definitions for Terms Related to Driving, J3016, September 2016.

Chapter 2 Automated Vehicle Classification, Terms, Acronyms, and Technologies

This chapter provides an explanation of the terms commonly used to identify and differentiate HAVs of varying capabilities at the time this report was published. Users of this report will benefit from familiarization with the terminology. See pages 12–13 for a list of acronyms.

A wide variety of vehicle technologies are available in the marketplace, and others are continually under development (e.g., forward collision warning, lane departure warning). This report does not attempt to define these specific vehicle technologies. Although there are technologies of a similar nature, some manufacturers use proprietary terms. Various resources, such as www.mycardoeswhat.org, provide information and videos of specific vehicle technologies.

Vehicle Classification Systems

AAMVA strongly encourages the adoption of terminology developed by SAE which is utilized throughout this report. Refer to the SAE taxonomy for additional information on each of the classifications.

SAE Classifications

SAE, which devises consensus standards for the engineering industry, established a six-tier classification system ranging from no vehicle automation to full vehicle automation. Each vehicle is expected to be classified within the six levels according to the following:

Level 0 – No Driving Automation, the performance by the driver of the entire dynamic driving task (DDT), even when enhanced by active safety systems.

Level 1 – Driver Assistance, the sustained and operational design domain (ODD)–specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.

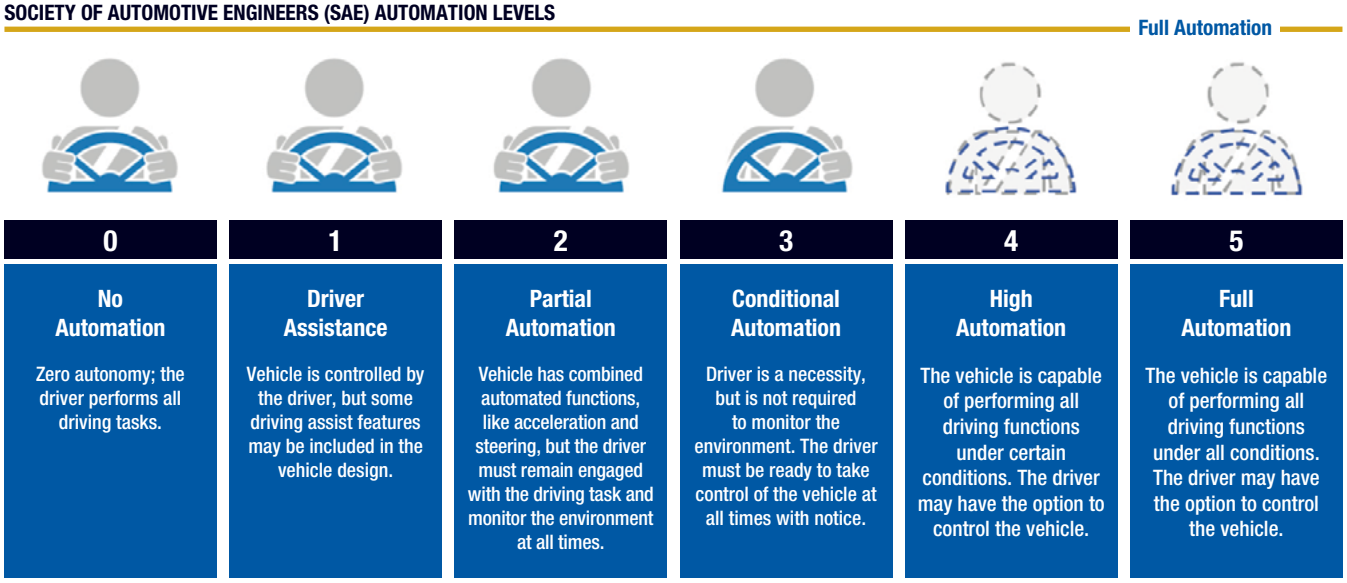
Level 2 – Partial Driving Automation, the sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the object and event detection and response (OEDR) subtask and supervises the driving automation system.

Level 3 – Conditional Driving Automation, the sustained and ODD-specific performance by an automated driving system (ADS) of the entire DDT with the expectation that the DDT fallback-ready user is receptive to ADS issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.

Level 4 – High Driving Automation, the sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.

Level 5 – Full Driving Automation, the sustained and unconditional (i.e., not ODD specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.

Summary of SAE International's Levels of Driving Automation for On-Road Vehicles



Source: National Highway Traffic Safety Administration, 2017

SAE Definitions

The following definitions are also provided by SAE to establish a baseline for commonly used terms and are also used throughout this report:

Automated driving system (ADS) – the hardware and software that are collectively capable of performing the entire DDT on a sustained basis, regardless of whether it is limited to a specific ODD; this term is used specifically to describe a Level 3, 4, or 5 driving automation system.

NOTE: In contrast to ADS, the generic term "driving automation system" refers to any Level 1 to 5 system or feature that performs part or all of the DDT on a sustained basis. Given the similarity between the generic term "driving automation system" and the Level 3 to 5-specific term "Automated Driving System," the latter term should be capitalized when spelled out and reduced to its acronym, ADS, as much as possible, while the former term should not be.

Driver – a user who performs in real-time part or all of the DDT and/or DDT fallback for a particular vehicle. NOTE: In a vehicle equipped with a driving automation system, a driver may in some vehicles assume or resume performance of part or all of the DDT from the driving automation system during a given trip.

Driving mode – type of vehicle operation with characteristic DDT requirements (e.g., expressway merging, high-speed cruising, low-speed traffic jam). Previously, the term "driving mode" was used; "ODD" is now the preferred term for many of these uses.

Dynamic driving task (DDT) – all of the real-time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints and including without limitation:

1. Lateral vehicle motion control via steering (operational);
2. Longitudinal vehicle motion control via acceleration and deceleration (operational);
3. Monitoring the driving environment via object and event detection, recognition,

classification, and response preparation (operational and tactical);

4. Object and event response execution (operational and tactical);
5. Maneuver planning (tactical); and
6. Enhancing conspicuity via lighting, signaling and gesturing, and so on (tactical).

Dynamic driving task (DDT) fallback – the response by the user or by an ADS to either perform the DDT or achieve a minimal risk condition after occurrence of a DDT performance-relevant system failure(s) or upon ODD exit.

(Human) user – a general term referencing the human role in driving automation.

Minimal risk condition – a condition to which a user or an ADS may bring a vehicle after performing the DDT fallback to reduce the risk of a crash when a given trip cannot or should not be completed.

Object and event detection and response (OEDR) – the subtasks of the DDT that include monitoring the driving environment (detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events (i.e., as needed to complete the DDT and/or DDT fallback).

Operate (a motor vehicle) – collectively, the activities performed by a (human) driver (with or without support from one or more Level 1 or 2 driving automation features) or by an ADS (Level 3-5) to perform the entire DDT for a given vehicle during a trip.

Operational design domain (ODD) – the specific conditions under which a given driving automation system or feature is designed to function, including, but not limited to, driving modes. An ODD may include geographic, roadway, environmental, traffic, speed, and/or temporal limitations. Previously, the term "driving mode" was used; "ODD" is now the preferred term for many of these uses.

Passenger – a user in a vehicle who has no role in the operation of that vehicle.

Request to Intervene – notification by the ADS to a driver indicating that s/he should promptly perform the DDT fallback.

Other Key Terms and Definitions

For purposes of this report, the following definitions apply:

Applicant – a person who applies for or requests a driver license permit or driver license.

Automated mode – the mode that is set in the vehicle in order for the automated actions to take over and the driver/user does not control the functions of the vehicle.

Automated vehicle (AV) – any vehicle equipped with autonomous technology that has been integrated into that vehicle.

Automated vehicle technology – technology that has the capability to drive a vehicle without the active physical control or monitoring by a driver.

Automated vehicle testing – testing of HAVs on public roadways.

Automation – the use of electronic or mechanical devices to replace a driver.

Background check – investigation of a candidate's background based on criteria determined by their prospective or current employer, which may include employment,

education, criminal records, credit history, motor vehicle, and license record checks.

Branding – adding words or phrases to a vehicle title document that describe an event that has impacted the vehicle value or ability to operate safely on the highway.

Crash (reportable crash) – a collision resulting in a person's injury or death or property damage that reaches the jurisdiction's threshold.

Crash report – a report completed by a law enforcement officer who investigates a motor vehicle crash.

Deploy/deployment/deployed – the operation of a vehicle on public roads by members of the public who are not employees, contractors, or designees of a manufacturer or other testing entity.

Driver history – record containing all convictions and other licensing actions of each driver maintained by the licensing jurisdiction.

Driver testing – the examination of an applicant to determine if s/he possesses the knowledge, skills and ability to safely operate a vehicle on public roadways.

Driver training – instruction provided to an individual on how to operate a vehicle safely.

Endorsement – an authorization to an individual's driver license permitting the individual to operate certain types of vehicles.

Event data recorder (EDR) – a device installed in some automobiles to record information related to vehicle crashes or incidents.

Highly automated vehicle (HAV) – vehicles that are monitored by the automated driving system and do not need a driver to operate but may allow for a driver to take control of the vehicle. These vehicles consist of SAE Level 3 Conditional Driving Automation, 4 High Driving Automation, and 5 Full Driving Automation.

Incident – an occurrence involving one or more vehicles in which a hazard is involved but not classified as a crash because of the degree of injury and/or extent of damage.

Jurisdiction – any state, district, territory, or province of the U.S. or Canada.

Manufacturer – an individual or company that designs, produces, or constructs vehicles or equipment. Manufacturers include original equipment manufacturers (OEMs), multiple and final stage manufacturers, upfitters (individuals or companies making changes to a completed vehicle before first retail sale or deployment), and modifiers (individuals or companies making changes to existing vehicles after first retail sale or deployment).

Manufacturer's safety plan – a clearly stated policy to help all employees understand the priority of developing safe and healthy working conditions and appropriate goals and objectives for the program.

Nondrivers – a user of an automated vehicle who normally would not be able to drive a vehicle (i.e., age limitations, disabilities).

Occupant – a human in the vehicle, regardless of role or responsibility.

Other entities and educational institutes – any individual or company, that is not a manufacturer, involved with helping to design, supply, test, operate, or deploy automated vehicles, technology, or equipment.

Rules of the road – phrase used to describe jurisdictional traffic laws.

Society of Automotive Engineers (SAE) International – an automotive and aerospace standard setting body that coordinates

development of voluntary consensus standards. See www.sae.org/about.

Skills test – a test to determine if the driver has a minimum level of skills to drive in most traffic situations while adhering to a jurisdiction's traffic laws.

Suspension – the temporary withholding of the license to drive, usually for a specified period of time.

Tier 1 supplier – direct suppliers to the original equipment manufacturer (OEM).

Upfitter – an individual or company that specializes in the design or installation of aftermarket products.

Violation – failure to follow jurisdictional laws or regulations.

Acronyms

American Association of Motor Vehicle Administrators (AAMVA)

American Association of State Highway and Transportation Officials (AASHTO)

American Driver and Traffic Safety Association (ADTSEA)

Association of National Stakeholders in Traffic Safety Education (ANSTSE)

Automated driving system (ADS)

Automated license plate readers (ALPR)

Automated vehicle testing (AVT)

Autonomous Vehicle Working Group (AVWG)

Canadian Council of Motor Transport Administrators (CCMTA)

Central processing unit (CPU)

Commercial Motor Vehicle Safety Standards (CMVSS)

Council of State Governments (CSG)

Department of Motor Vehicles (DMV)

Department of Transportation (DOT)

Driving School Association of the Americas (DSAA)

Electric and hydrogen-fueled vehicles (xEVs)

Event data recorder (EDR)

Emergency medical services (EMS)

Federal Motor Vehicle Safety Standards (FMVSS)

Global Positioning System (GPS)

Governors Highway Safety Association (GHSA)

Highly automated vehicle (HAV)

International Association of Chiefs of Police (IACP)

International Driver Examiner Certification (IDEC)

International Organization for Standardization (ISO)

Manufacturer's Certificate of Origin (MCO)

Manufacturers and other entities (MOE)

Manufacturer's statement of origin (MSO)

Model minimum uniform crash criteria (MMUCC)

Motor vehicle agency (MVA)

National Conference of State Legislatures (NCSL)

National Fire Protection Association (NFPA)

National Governors Association (NGA)

National Highway Traffic Safety Administration (NHTSA)

National Motor Vehicle Title Information System (NMVTIS)

Noncommercial model driver testing system (NMDTS)

Notice of proposed rulemaking (NPRM)

Novice Teen Driver Education and Training Administrative Standards (NTDETAS)

Object and event detection and response (OEDR)

Original equipment manufacturer (OEM)

Society of Automotive Engineers (SAE)

Test Maintenance Subcommittee (TMS)

Transportation Research Board (TRB)

United States Department of Transportation (U.S. DOT)

Vehicle identification number (VIN)

Chapter 3 Administrative Considerations

3.1 Administration

Background

To successfully address the safe integration of HAVs within the transportation system, a collaborative approach should be taken among jurisdictions and stakeholders to gain an understanding of emerging vehicle technologies and the impact to roadway safety, jurisdictional programs, and infrastructure.

Guidelines for Testing HAVs

A lead agency should be identified within each jurisdiction to address HAV testing and deployment within its borders. The lead agency should be charged with establishing a jurisdictional HAV committee. The committee should include, but may not be limited to, representatives from the:

- governor's or chief executive's office,
- legislature,
- motor vehicle administration,
- department of transportation,
- jurisdiction law enforcement agency,
- office of highway safety,
- office of information technology,
- insurance regulator,
- office(s) representing the aging and disabled community,
- toll authorities,
- transit authorities, and
- local government.

Other stakeholders such as transportation research centers, located within the jurisdiction, and groups representing pedestrians and bicyclists should be consulted as appropriate. Communication with the HAV manufacturing industry is encouraged.

The jurisdiction's HAV committee should develop strategies for addressing the testing and deployment of HAVs in their jurisdiction. There are a range of strategies to consider from addressing testing without active regulation to testing with regulation by policy or statute.

Jurisdictions will need to examine their laws and regulations to address unnecessary barriers to safe testing, deployment and operation of HAVs in the areas of:

- licensing and registration;
- driver education and training;
- financial responsibility (insurance and liability);
- enforcement of traffic laws and regulations; and
- administration of motor vehicle inspections.

Jurisdictions that regulate the testing of HAVs are encouraged to take necessary steps to establish statutory authority and to use NHTSA's *Automated Driving Systems: A Vision for Safety 2.0* published in September 2017 and later updates to frame the regulations.

The designated lead agency should keep its HAV committee informed of requests from manufacturers or other entities to test in their jurisdiction and the status of the designated agency's response.

Several national associations are engaged in the discussion on HAVs and are available for additional support to jurisdictional government officials. These include, but are not limited to AAMVA, the American Association of State Highway and Transportation Officials (AASHTO), CCMTA, the Council of State Governments (CSG), National Conference of State Legislatures (NCSL), Governors Highway Safety Association (GHSA), and the National Governors Association (NGA).

As technologies emerge, regulators and legislators will need to continuously advance their knowledge, staying abreast of relevant reports and studies, attending HAV forums, and engaging with industry. This knowledge will help officials recognize when laws, rules, and policies are outdated or proposed prematurely.

Recommendations for Jurisdictions

3.1.1. Identify a lead agency to manage the HAV committee and its efforts.

3.1.2. Establish an HAV committee.

3.1.3. Develop strategies for addressing testing and deployment of HAVs in the jurisdiction.

3.1.4. Examine jurisdictional laws and regulations to consider barriers to safe testing, deployment, and operation of HAVs.

3.1.5. Jurisdictions that regulate the testing of HAVs are encouraged to take necessary steps to establish statutory authority and to use NHTSA's *Automated Driving Systems: A Vision for Safety 2.0* and later updates to frame the regulations.

3.1.6. HAV committee members, regulators, and legislators are encouraged to perform knowledge-gathering and information-sharing functions.

Recommendations for Manufacturers and Other Entities

MOE 1. Manufacturers and other entities should interact with and respond to jurisdictional HAV committee questions and requests.

Benefits to Implementation

By establishing a lead agency and an HAV committee, jurisdictions optimize collaboration among stakeholders as they become informed of the technologies and as they explore options for the safe testing and deployment of HAVs. Awareness will assist officials to recognize when and how regulations will need to be developed and updated. A lead agency can provide the appropriate level of government oversight with flexibility to quickly modify regulations if needed. A flexible and consistent approach is beneficial to regulators and supports innovation within the industry.

Challenges to Implementation

Finding the right balance between ensuring roadway safety while supporting technological advancements through the development and testing phases of HAVs is a challenge. Thorough review of jurisdictional laws and rules to ensure the safe testing of HAVs in as many situations as possible, including testing without a driver, will require a resource commitment by jurisdictions.

Chapter 4 Vehicle Credentialing Considerations

4.1. Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways

Background

Several jurisdictions have enacted statutes and rules that give qualifying manufacturers and other entities authority to test automated vehicles on their public roadways. What follows is a recommended framework to achieve consistency among those jurisdictions that opt to require a permit for testing HAVs.

Guidelines for Testing Vehicles

Manufacturers and other entities testing Level 3, 4, and 5 HAVs should apply for and be issued vehicle specific test permits before testing on public roadways.

The application process for test permits is intended to provide sufficient background information for jurisdiction and law enforcement personnel to interact with the manufacturer and its vehicle(s). It is vital for jurisdictions and law enforcement to know who, how, where, and what testing is being conducted. It is recommended the permit application process include the completion or attachment of the following information:

- Name of manufacturer or other entity
- Corporate physical and mailing addresses of manufacturer or other entity
- In-jurisdiction physical and mailing addresses of manufacturer or other entity, if different than corporate address
- Program administrator or director
- Contact information for program administrator or director
- Vehicle specific information for all vehicles to be permitted including:
  - Vehicle identification number (VIN)
  - Year (if assigned by the manufacturer)
  - Make (if assigned by the manufacturer)
  - Model (if assigned by the manufacturer)
  - License plate number and jurisdiction of issuance (if applicable)
  - Indication of intention for testing with or without a human controlling the vehicle from within the vehicle, and SAE level if testing without a human driver
  - Vehicle type (passenger, commercial, or low speed)
- List of all drivers of Level 3, 4, and 5 vehicles, including:
  - Full name
  - Date of birth
  - Driver license number and jurisdiction or country of issuance
- Summary of training provided to employees, contractors, or other persons designated by the manufacturer or other entity as drivers of test vehicles

- Disclosure of all jurisdictions where application or issuance of testing registration permits has occurred or been denied
- Self-certification of prior testing of the technology to be used in the test vehicles under controlled conditions which simulate the real-world conditions (various weather, types of roads, and times of the day and night) the manufacturer intends to subject the vehicle to on public roadways
- Certification that each test vehicle complies with all FMVSS or CMVSS (see Section 4.7)
- Copy of manufacturer's safety plan for testing vehicles including a minimal risk condition component
- Routes to be used when testing Level 3, 4, or 5 vehicles without a human controlling the vehicle from within the vehicle (if applicable)
- Evidence of the manufacturer's ability to respond to judgments for damages for personal injury, death, or property damage caused by a vehicle during testing. Evidence may be in the form of an instrument of insurance, a surety bond, or proof of self-insurance.

Such permits should be valid in the jurisdiction of issuance only. Each permit, subject to periodic renewal, should contain the following information:

- Owner name
- Mailing and physical addresses
- Emergency contact information
- Jurisdiction specific limitations (e.g., geographic, environmental)
- VIN
- Year of vehicle (if assigned by the manufacturer)
- Make of vehicle (if assigned by the manufacturer)
- Model of vehicle (if assigned by the manufacturer)
- Vehicle type (passenger, commercial, or low-speed)
- Indication of permit holder's intention for testing with or without a human controlling the vehicle from within the vehicle and SAE level if testing without a human driver

In jurisdictions where manufacturer or other entity-owned vehicles are required to be individually registered, the permit information should be available for verification at time of vehicle registration issuance (new and renewal) either by presentation from the holder or through electronic means. If at any time such a permit is no longer valid, the associated vehicle registration should become void.

Permits should be carried in the test vehicle while present on public roadways. Permit information should be made readily available to law enforcement via electronic means by the issuing jurisdiction.

Recommendations for Jurisdictions

4.1.1. Require all manufacturers and other entities testing Level 3, 4, or 5 HAVs to apply for and be issued vehicle specific permits before testing on public roadways.

4.1.2. Establish a test registration permit application process for HAVs that does not create unnecessary barriers for manufacturers or other entities and requires the completion or attachment of the information listed in Section 4.1.

4.1.3. Require test registration permit information be available for verification at the time of vehicle registration issuance (new and renewal) either by presentation from the

holder or through electronic means in jurisdictions where manufacturer or other entity-owned vehicles are required to be individually registered.

4.1.4. Require test registration permits to be carried in the test vehicle while present on public roadways within their jurisdiction. Permit information should be made readily available to law enforcement via electronic means by the issuing jurisdiction.

Guidelines for Deployed Vehicles

Deployed vehicles are not subject to permit issuance.

Benefits of Implementation

Automated vehicles tested on public roadways will meet minimum testing requirements before authorized operation. In addition, authority granted for on-road testing will be identifiable to law enforcement and MVAs.

Challenges to Implementation

Some manufacturers may resist these recommendations and may indicate regulations or permit issuance are not necessary if vehicles being operated are properly registered or plated.

4.2 Vehicle Registration

Background

Vehicle registration credentials and records are basic tools that enable identification of a vehicle and its owner. As testing and deployment of HAVs expand, the need for owner and vehicle information is necessary to distinguish these vehicles in mixed-fleet operations. Several jurisdictions already require the use of special registrations for HAVs tested on public roadways.

Guidelines for Testing Vehicles

Uniform language should be established to aid law enforcement, the MVA, and other stakeholders in identifying these vehicles. Such language should use common terminology such as "HAV" for "highly automated vehicle" and Levels 3, 4, and 5.

These notations should appear on the vehicle registration credential and electronic record. Jurisdictions should also consider using a separate field for such notation (review *AAMVA's Best Practice for Registration Credentialing* for suggestions on open fields).

The registration, title, and plate issued by the titling jurisdiction for purposes of HAV testing should be recognized by other jurisdictions to offer manufacturers process efficiencies and enhance interjurisdictional testing.

Recommendations for Jurisdictions

4.2.1. Establish uniform language that will benefit law enforcement, the MVA, and other stakeholders for testing HAVs. Such language should use common terminology such as "HAV" for "highly automated vehicle" and Levels 3, 4, and 5.

4.2.2. Place a notation on the registration credential or electronic record of vehicles that have the capability to operate at Level 3, 4, or 5.

4.2.3. Recognize the registration, title, and plate issued by another titling jurisdiction for purposes of testing.

Guidelines for Deployed Vehicles

A field should be established on the registration credential or record for motor vehicles with Level 3, 4, and 5 functionality, indicating the motor vehicle has automated capabilities, including vehicles that can operate without a human driver.

Uniform language should be established to aid law enforcement, the MVA, and other stakeholders in identifying these vehicles. Such language should use common terminology such as "HAV" for "highly automated vehicle" and Levels 3, 4, and 5.

Additionally, jurisdictions should consider using a separate field for this notation (review *AAMVA's Best Practice for Registration Credentialing* for suggestions on open fields). See the next section on Titling and Branding for New and Aftermarket Automated Vehicles for more information.

Recommendations for Jurisdictions

4.2.4. Establish a field on the registration credential or record for deployed vehicles that indicates the motor vehicle has automated capabilities, including vehicles that can operate without a human driver.

4.2.5. Establish uniform language to aid law enforcement, the MVA, and other stakeholders. Such language should use common terminology such as "HAV" for "highly automated vehicle" and Levels 3, 4, and 5.

4.2.6. Consider using a separate field for HAV notation on the registration or credential for deployed vehicles (review *AAMVA's Best Practice for Registration Credentialing* for suggestions on open fields). See Section 4.3 Titling and Branding for New and Aftermarket Highly Automated Vehicles for more information.

Benefits of Implementation

Disclosure of a vehicle as an HAV on the registration credential allows law enforcement to quickly and accurately identify vehicles during a traffic stop or at a vehicle crash scene. Additionally, the HAV notation can be maintained until a national solution, such as a VIN check digit or indicator, is established (see Section 4.5 Highly Automated Vehicle Information on the Manufacturer's Certificate of Origin [MCO] or Manufacturer's Statement of Origin [MSO]).

The HAV indicator on registration records also improves HAV summary data reporting. This could include total number of HAVs registered in each jurisdiction and number of HAVs involved in crashes and violations. This data can be useful when analyzing the impacts of HAV highway safety statistics, adoption rates, and revenue projections.

Challenges to Implementation

Registration and titling are closely linked. When jurisdictions are considering how to manage registrations, they should also review their titling process. See Section 4.3 Titling and Branding for New and Aftermarket Highly Automated Vehicles. As technology progresses and the availability of aftermarket automation products becomes available or technology is not kept up to date, the level of autonomy of a registered vehicle may change over time. Vehicle software updates or upgrades may complicate the registration process, such as increasing the level of automation or decreasing the level of automation. Neither the MCO nor the VIN currently provides an HAV identifier.

4.3 Titling and Branding for New and Aftermarket Highly Automated Vehicles

Background

Although much has been written about HAVs, there has been limited dialogue on titling and branding of such vehicles. Even though jurisdictions may choose to take a "wait and see" approach on some issues, titling and branding is one subject jurisdictions can and should be considering now.

Guidelines for Testing Vehicles

Although numerous jurisdictions have enacted laws pertaining to HAVs, only a few have ventured into

the field of allowing the testing of such vehicles. Generally, jurisdictions do not require titling of a motor vehicle until it has been sold. There is no reason to change this practice for HAVs.

Even though a jurisdiction may not title test vehicles, the jurisdiction should record and maintain the vehicle information in its vehicle record either through the normal titling process through a titling exception process unique to HAVs or recording vital information in the registration record without titling.

If a jurisdiction chooses to title an HAV, the title should carry the brand HAV to indicate "highly automated vehicle." Storing information, such as the VIN and an HAV brand, whether through titling or some other method devised by the jurisdiction:

- provides pertinent information to stakeholders in case of a crash;
- ensures ownership transfer of the vehicle will be within its laws or policies[1]; depending on how a jurisdiction wants to treat a post test vehicle[2];
- provides information to the National Motor Vehicle Title Information System (NMVTIS) so the status of the vehicle is readily available to other jurisdictions[3]; and
- provides pertinent information to law enforcement.

For vehicles not equipped with automated technologies by the original equipment manufacturer (OEM), branding of vehicles with aftermarket-altered automated technologies is recommended. In many jurisdictions, when a vehicle is significantly altered with aftermarket components or the vehicle no longer physically represents the manufacturer's vehicle, a vehicle title record is "branded" as reconstructed. Vehicles that have had a Tier 1 supplier or an aftermarket company significantly alter the vehicle with automated technologies enabling HAV functionality (Levels 3, 4, and 5) should be identified or "branded" for law enforcement and MVAs. California, for example, requires branding as a regulatory tool for tracking the final disposition of the vehicle once it is no longer used for testing. This applies to manufacturers as well as Tier 1 suppliers and other aftermarket companies.

Additionally, it has been suggested vehicles with lower automated vehicle functionality (Level 3) may have the ability to have their ADS upgraded to higher levels of functionality (e.g., move to Level 4 or 5). In these scenarios, capturing this increased functionality will be necessary to properly reflect the vehicles new HAV functionality. Jurisdictions should use the process described in this section for aftermarket modification to record this information.

As automated technologies continue to develop, jurisdictions should make a notation on a vehicle's record using "HAV" for "highly automated vehicle" *when* the altered vehicle is capable of functioning at a Level 3, 4, or 5.

Recommendations for Jurisdictions

4.3.1. Record and maintain the test vehicle information in the vehicle record through the normal titling process, through a titling exception process unique to HAVs, or recording vital information in the database without titling. If a jurisdiction titles an HAV, the brand should indicate "highly automated vehicle."

4.3.2. Titles for vehicles with added aftermarket components enabling HAV functionality should be branded. The brand should indicate "highly automated vehicle."

1 Unless information is accessible to all DMV employees, a post-test vehicle may be transferred contrary to the jurisdiction's laws or policies.

2 California restricts the transfer to: a manufacturer holding a valid autonomous vehicle Manufacturer's Testing permit; a manufacturer wishing to dispose of the vehicle must obtain a Non-repairable Vehicle Certificate, and ownership is transferred to an auto dismantler, or the vehicle is transferred to an educational or research institution or museum for display or study. California Vehicle Code §227.50. It is recommended that jurisdictions follow California's lead or brand the vehicle junk. However, without the automated vehicle testing (AVT) branding, a jurisdiction would not have the knowledge to subsequently place the appropriate brand on the vehicle.

3 If NMVTIS does not recognize automated branding, it is still important for jurisdictions to be able to distinguish automated from non-automated vehicles.

4.3.3. Make a notation on a vehicle's record using "HAV" when the altered vehicle is capable of functioning at a Level 3, 4 or 5 as automated technologies continue to develop.

Guidelines for Deployed Vehicles

All HAVs, including those altered by aftermarket part manufacturers or ADS technology companies, should be titled pursuant to the jurisdiction's laws or policies and the title should be branded HAV and further designated by Level 3, 4, or 5. Uniform language, referenced in Section 4.2 Vehicle Registration, is recommended for proper disclosure from jurisdiction to jurisdiction. This guideline is especially significant if exemptions are created for activities currently prohibited (e.g., driving without a license if suspended or revoked privilege; issues related to medical fitness, texting, cell phone use, or display screen content streaming).

For consistent jurisdictional title branding, it is recommended the OEM or the installer of the aftermarket automated technology (either parts or software) be required to notify the MVA when a motor vehicle has been altered by adding the automated vehicle technology.

Recommendations for Jurisdictions

4.3.4. Title all highly automated deployed vehicles, including those altered by aftermarket part manufacturers, pursuant to the jurisdiction's laws or policies; each title should be branded "HAV" and further designated by Level 3, 4, or 5.

Recommendations for Manufacturers and Other Entities

MOE 2. The OEM or the installer of the aftermarket automated technology, either parts or software systems, should notify the MVA when a motor vehicle has been altered by adding the automated vehicle technology.

Benefits of Implementation

Traditionally, jurisdictions have used title branding as a mechanism to identity unique events or qualities that impact the value or safety aspects of a vehicle. Using a proven and existing process to identify HAVs will ease implementation and adoptability for jurisdictions.

Disclosure via title branding allows law enforcement, MVA personnel and other stakeholders the ability to better identify vehicles with automated functionality. Additionally, title branding will provide a mechanism for sharing the information between jurisdictions until a national solution, such as a VIN check digit or indicator, becomes available.

Challenges to Implementation

Each jurisdiction has its own unique method of titling and registering vehicles. There is no one guideline that will fit all jurisdictional processes.

Special Considerations

Titling and registration are closely linked. When jurisdictions are considering how to manage titling, they should also review their registration process. See Section 4.2 Vehicle Registration.

With the increased technological functionality of these vehicles, jurisdictions may need to consider new types of requirements for HAVs such as the repair of vehicles returning to road use after severe crashes. HAVs involved in severe crashes may require evaluation and certification by the manufacturers' authorized repair technicians before being authorized to return to service or for proper "rebuilt" title branding purposes.

4.4 License Plates

Background

License plates serve a common purpose—to identify motor vehicles. Any jurisdiction that adopts a license plate design specifically for HAVs should design the

plates for automated license plate readers (ALPR) and optimal legibility to the human eye. The ability for MVA employees, police officers, tolling authorities, and citizens to quickly and easily identify license plate numbers is fundamental to accurate vehicle registration data creation, maintenance, retrieval, and eyewitness reporting.

Guidelines for Testing and Deployed Vehicles

Special license plates for HAVs do not need to be required. However, if they are required, the plates should adopt the administrative, design, and manufacturing specifications contained in the *AAMVA License Plate Standard*.

Recommendations for Jurisdictions

4.4.1. Jurisdictions should not require a special license plate for HAVs. However, if a jurisdiction chooses to require a special license plate for HAVs, the plates should adopt the administrative, design, and manufacturing specifications contained in the *AAMVA License Plate Standard*.

Benefits of Implementation

There is limited benefit for implementing a special license plate for HAVs as long as the jurisdiction follows the recommendation on registration credential notation from Section 4.2 Vehicle Registration.

Challenges to Implementation

Challenges in implementing a new license plate design include the identification of the jurisdiction of issuance; discernibility of the plate design from others it issues; and cost if there is special significance to the license plate design, as in the design for an HAV license plate.

4.5 Highly Automated Vehicle Information on the Manufacturer's Certificate of Origin and Manufacturer's Statement of Origin

Background

MCO and MSO documents are used by the vast majority of jurisdictions for titling and registering process of a new motor vehicle. In Canada, jurisdictions use an equivalent document referred to as the New Vehicle Information Statement (NVIS). The MCO, MSO, or NVIS format is not governed by federal statute or rule; however, most jurisdictions have statutes or rules governing their appearance, content, and acceptance. AAMVA provides jurisdictions and manufacturers with general guidance through AAMVA policy positions to promote uniformity among jurisdictions.

Typically, the MCO, MSO, or NVIS contains, at a minimum, issue date of certificate, control or certificate number, VIN, model, make, series or model, and body style. Furthermore, MCOs/MSOs/NVISs list engine horse power, engine displacement or number of cylinders, gross vehicle weight rating (GVWR,) and shipping weight, as well as the manufacturer's name and address and the dealership name and address where the vehicle was initially delivered. The back of the document contains sales reassignment areas for the purchaser (whether a retail customer or a subsequent dealer). MCOs/MSOs/NVISs are generated on security paper similar to jurisdictional title stock.

Guidelines for Testing Vehicles

Manufacturer test vehicles are often not titled. Currently, only California requires the titling of a test vehicle when used in the automated vehicle testing program, which ensures the proper tracking and eventual disposal of the vehicle when no longer used for testing.

Recommendations for Jurisdictions

4.5.1. Jurisdictions should not initiate a process for titling test vehicles if the jurisdiction does not already require this protocol.

Guidelines for Deployed Vehicles

AAMVA supports NHTSA's *Automated Driving Systems: A Vision for Safety 2.0* recommendation that various levels of government and private industry continue to collaborate and cooperate in meeting identification goals for HAVs entering the marketplace. Developing a process for identifying HAV functionality through the VIN directly from the manufacturer is crucial to meeting this goal; however, it will require NHTSA to make rule changes to VIN requirements. In conjunction with a VIN identifier, it is recommended vehicle manufacturers list automated capabilities on the MCO, MSO, or NVIS. This information should be listed in a new field on the MCO, MSO, or NVIS to avoid confusion with existing content.

Recommendations for Manufacturers and Other Entities

MOE 3. Vehicle manufacturers should list automated capabilities on the MCO, MSO, or NVIS. This functionality should be listed in a new field on the MCO, MSO, or NVIS to avoid confusion with existing information.

Benefits of Implementation

Using information from a MCO, MSO, or NVIS provides each MVA with certainty that the manufacturer has certified the vehicle's HAV functionality level. Additionally, this information would be available to every jurisdiction in the same format.

Challenges to Implementation

Changing VIN requirements will involve NHTSA adopting a rule change, and some jurisdictions will require software changes to accommodate changes in VIN.

4.6 Financial Responsibility

Background

An important element of the administration and regulation of HAVs is ensuring adequate insurance is in place to protect not only the occupants of an HAV but also other road users. For example, many jurisdictions require a minimum financial responsibility (otherwise known as insurance and liability) requirement for each vehicle operating on public roads.

Motor vehicle regulators should monitor the legal trends ensuring limits stay relevant and appropriate. It is advisable that there be sufficient coverage available for third-party liability in jurisdictional scenarios where there is no explicit distinction in property damage versus personal injury.

Guidelines for Testing Vehicles

All HAVs permitted for on-road testing should be required to have minimum liability insurance in the form and manner required by the MVA authority.

Recommendations for Jurisdictions

4.6.1. Require all HAVs permitted for on-road testing to have minimum liability insurance in the form and manner required by the MVA authority.

Guidelines for Deployed Vehicles

Minimum liability insurance should follow current jurisdictional requirements.

Recommendations for Jurisdictions

4.6.2. Follow current requirements for minimum liability insurance for deployed vehicles.

Benefits of Implementation

Requiring a minimum liability insurance level for HAV testing provides consistency among jurisdictions. This prevents prospective companies from seeking out jurisdictional testing locations that do not require any liability coverage. Furthermore, the public will be given some assurance that companies interacting on the public roadways are testing in a responsible manner.

Challenges to Implementation

Different liability limits between jurisdictions can create incentives for HAV testing where the liability level is the lowest or is not required, placing the public at risk and possibly dissuading adoption of this technology by the public. Although not in scope for these recommendations, the increase in commercial motor vehicle HAV testing interest has many jurisdictions considering if the potential for greater damage in a crash necessitates a higher minimum insurance liability limit.

4.7 Federal Motor Vehicle Safety Standards (FMVSS) and Canadian Motor Vehicle Safety Standards (CMVSS)

Background

Title 49 of the United States Code, Chapter 301, Motor Vehicle Safety, legislatively mandates NHTSA to issue FMVSS and Regulations to which manufacturers of motor vehicle and equipment items must conform and certify compliance. FMVSS 209 was the first standard to become effective on March 1, 1967. New standards and amendments to existing standards are published in the *Federal Register*.

These federal safety standards establish minimum safety performance requirements for motor vehicles or items of motor vehicle equipment. These requirements are specified in such a manner "that the public is protected against unreasonable risk of crashes occurring as a result of the design, construction or performance of motor vehicles and is also protected against unreasonable risk of death or injury in the event crashes do occur."[4]

These recommendations also apply to the CMVSS.

Guidelines for Testing Vehicles

Certifying vehicles conform to all applicable FMVSS or CMVSS is a critical element for manufacturers or other entities testing HAVs for operation within jurisdictions.

Recommendations for Jurisdictions

4.7.1. Consider requiring manufacturers or other entities testing HAVs within the jurisdiction to certify the vehicles comply with all applicable FMVSS or CMVSS and no required safety devices have been made inoperable. In lieu of the certification, evidence the vehicle(s) have been exempted from the regulations may be required.

Benefits of Implementation

HAVs tested on public roadways and sold to consumers will meet minimum federal safety standards.

Challenges to Implementation

Some manufacturers may indicate safety standards do not apply to their vehicle technology. Manufacturers should apply for a specific exemption from NHTSA if they do not believe their vehicle should be held to these standards.

Special Considerations

As technology and vehicle designs evolve, it will be important for FMVSS and CMVSS to keep pace. Jurisdictions should partner with federal agencies to assist and support the common goal of encouraging technological innovation while increasing safety and mobility.

4 Forward from U.S. Code 49 Part 571.

Chapter 5 Driver Licensing Considerations

5.1 Driver and Passenger Roles Defined

Background

All stakeholders should use common terminology and definitions for HAVs to better facilitate discussions. As described in Chapter 2, this report uses the SAE International's definitions.1 NHTSA has also adopted the SAE International definitions. Universal terms and definitions are critical for jurisdictions, manufacturers, and other entities when discussing automated vehicle technologies and HAVs. It should be noted this report uses the terms "driver" or "user." Although use of the term "operate" or "operating" implies the existence of an "operator," this term is not defined or used in this document, consistent with SAE International definitions and use of terms.

Recommendations for Jurisdictions

5.1.1. Use the SAE International definitions1 provided in Chapter 2.

Recommendations for Manufacturers and Other Entities

MOE 4. Manufacturers and other entities should use the SAE International definitions1 provided in Chapter 2.

Benefits of Implementation

Universal definitions of these terms will facilitate communication, understanding, and standardization of roles and responsibilities for HAVs.

Challenges to Implementation

Educating all entities on the need for acceptance and implementation of these universal terms and definitions will be an implementation challenge.

Jurisdictions will need to review jurisdiction laws and regulations ensuring motor vehicle laws permit the operation of Level 4 and 5 vehicles without a driver. Legislative action amending statutory and regulatory definitions of "driver" and related terms and reviewing and adapting existing rules regarding vehicle operation may pose challenges until more policymakers are versed in the subject matter.

5.2 Driver License Requirements for Testing by Manufacturers and Other Entities

Background

Currently, there are numerous manufacturers and other entities testing HAVs in multiple jurisdictions. It is anticipated that testing will be expanded to include most jurisdictions. This section provides guidelines for testing HAVs by manufacturers and other entities.

Guidelines for Testing by Manufacturers and Other Entities

HAVs should be operated solely by employees, contractors, or other persons designated by the HAV manufacturer or other entities, such as universities involved in testing. Test drivers of Level 3, 4, and 5 vehicles should receive training and instruction related

to, but not limited to, the capabilities and limitations of the vehicle and should be subject to a background check as described in Section 6.2 Criminal Activity. Training should be documented and submitted to the jurisdiction's HAV lead agency along with other required information. Jurisdictions may need to develop or review and adapt their existing rules for submission of such information and background checks.

Because the design of some Level 4 and 5 vehicles may not include a driver's seat or equipment that enables actual physical control of the vehicle's operations, jurisdictions will need to support the safe testing without a human driver inside the vehicle. In this case, the jurisdiction should require a user designated by the manufacturer or any such entity involved in the driverless testing of the HAV is capable of assuming control of the vehicle's operations or has the ability to achieve a minimal risk condition. Mandating these features (e.g., driver's seat or equipment) may entail changes to the design of vehicles that simply are not possible; even if possible, equipping these vehicles with the additional features will result in test vehicles being configured differently than those ultimately sold to or used by consumers. The safe testing of HAVs without a driver's seat or other equipment is essential to the continued research and design leading to the eventual deployment of HAVs.

Jurisdictions will need to take the appropriate steps to ensure that their motor vehicle laws allow for the testing of Level 3, 4, and 5 vehicles and for Level 4 and 5 vehicles by someone who is not a driver and who is not licensed as a driver. This may require amending statutory and regulatory definitions of "driver" and other related terms.

These guidelines are not relevant to Level 0 to 2 vehicles unless otherwise noted.

Recommendations for Jurisdictions

For Level 3 to 5 vehicles, the following guidelines are provided:

5.2.1. Review and develop or adapt existing rules, if applicable, regarding vehicle operation to ensure HAV testing is permitted.

5.2.2. Require test HAVs be operated solely by employees, contractors, or other persons designated by the manufacturer of the HAV or any such entity involved in the testing of the HAV.

5.2.3. Require test drivers to receive training and instruction related to, but not limited to, the capabilities and limitations of the vehicle and be subject to a background check as described in Section 6.2 Criminal Activity.

5.2.4. Require training provided to the employees, contractors, or other persons designated by the manufacturer or entity be documented and submitted to the jurisdiction's HAV lead agency along with other required information.

5.2.5. Support the safe testing without a human driver inside of the vehicle by requiring a user designated by the manufacturer of the ADS technology or any such entity involved in the driverless testing of the HAV to be capable of assuming control of the vehicle's operations or have the ability to achieve a minimal risk condition.

5.2.6. Take steps to ensure motor vehicle laws allow for the manufacturer to safely test Level 4 and 5 vehicles without a licensed driver, provided a user designated by the manufacturer or any such entity involved in the driverless testing of the HAV is capable of assuming control of the vehicle's operations or has the ability to achieve a minimal risk condition.

Recommendations for Manufacturers and Other Entities

MOE 5. Manufacturers and other entities should complete a background check and provide or ensure appropriate training for HAV test drivers. See Section 6.2 Criminal Activity on background checks.

Benefits of Implementation

The review of jurisdictional laws and rules regarding vehicle operation to ensure HAV testing is permitted will benefit the safe testing and deployment of HAVs. Test driver training is a key element for the safe testing of HAVs. Thorough testing of HAVS by manufacturers and other entities in as many situations as possible will support the safe deployment of HAVs to consumers.

Challenges to Implementation

Challenges to implementation include the review of jurisdictional laws and rules regarding vehicle operation for the testing of HAVs and educating manufacturers on the process for submitting required documentation.

5.3 Driver Training for Consumers of Deployed Vehicles

Background

The operation of HAVs by consumers will have significant implications for driver training. As HAVs are deployed and become available to the public, drivers will need to receive proper training on the operation and limitations of their HAV.

Who has the responsibility for training the consumer should be determined. Consumer training may be achieved by one or more of the following:

- Consumers to seek the appropriate HAV driver training from a recognized professional;
- Manufacturers, dealers and other appropriate entities to provide adequate HAV driver training to consumers; and
- Jurisdictions to regulate HAV driver training for consumers.

The appropriate entities need to develop quality HAV driver training programs that will effectively train consumers to operate HAVs safely and reasonably. The training should educate consumers on the limitations and capabilities of HAVs, how to engage and disengage the system functions, risks of misuse, and how to deal with emergency situations related to the HAV. The training should encompass all safety features to ensure consumers will use the products within the established parameters.

Guidelines for Deployed Vehicles

Communication and education among new, used and aftermarket dealers, manufacturers, and consumers on HAV functions are critical elements for the safe operation of these vehicles. Dealers will need to ensure vehicle information and content contained in the vehicle "owner's manual" is fully available and reviewed with consumers. However, familiarity of the information and content is not sufficient and should not replace applicable driver training on HAV functions.

Jurisdictions will need to encourage manufacturers and dealers to provide proper training to the fullest extent for consumers. Jurisdictions may also need to encourage manufacturers and dealers to offer incentives to consumers to seek training from a fully qualified driving instructor. Insurance companies may also provide discount incentives.

Agreement on a minimum set of training requirements, outside of the normal owner's manual, will have a direct impact on the success of HAV technology. Many dealerships already provide personal training classes on features of the vehicle

for their customers. Standardized training should be available to everyone who purchases or has the technology installed on their vehicles. In addition to these jurisdictional guidelines, stakeholder consultation is highly recommended.

Recommendations for Jurisdictions

5.3.1. Promote consumer training on the use of HAV functions.

5.3.2. Encourage communication between dealers and consumers including, but not limited to, acknowledgement of the sections in the vehicle "owner's manual" that relate to the HAV functions.

5.3.3. Encourage manufacturers, dealers, and insurance companies to provide incentives for consumers to receive proper training on the use of HAV functions.

Benefits of Implementation

Consumers who are properly educated on the HAV functions, limitations, and capabilities of their vehicle, including how to engage and disengage the system functions, risks of misuse, and how to deal with emergency situations related to the HAV, will support the safe deployment of HAVs.

Challenges to Implementation

Challenges to implementation include educating consumers on the importance of obtaining training on their HAV functions and buy-in from manufacturers, dealers, and insurance companies to provide training or to offer incentives to consumers to seek training.

5.4 HAV Driver Training for Motor Vehicle Agency Examiners, Driver Education Programs, and Private Instructors

Background

HAV technologies have developed at a rapid pace. The training of driver license examiners on these technologies should keep pace with this evolution. HAV technologies have many implications for the driver license testing process.

Additionally, the training of driver education teachers and instructors, as well as driver education curricula, should evolve with HAV technologies. National organizations that play a key role in the development of curricula and teacher or instructor training include the:

- American Automobile Association (AAA),
- American Driver and Traffic Safety Association (ADTSEA), and
- Driving School Association of the Americas (DSAA).

AAMVA plays a major role in assisting jurisdictions with driver testing practices and driver license examiner training. The Association of National Stakeholders in Traffic Safety Education (ANSTSE) develops standards and free resources to assist jurisdictions in their driver education efforts.

The AVWG will assist the AAMVA Test Maintenance Subcommittee (TMS) to update model driver manuals, knowledge tests, and skills tests to address the use of vehicle technology during driver testing. There are also plans for the AVWG to assist the AAMVA International Driver Examiner Certification (IDEC) Board to update the driver license examiner training materials to address vehicle technology as it emerges.

Guidelines for Deployed Vehicles

- **Jurisdictional Examiners**

  It is important that jurisdictions ensure driver license examiners are familiar with vehicle technologies. As automated vehicle technologies continue to advance, the training of driver license examiners will need to keep pace with these advancements. Training will need to be updated on a regular basis as the technologies continue to evolve. Refer to AAMVA's IDEC model training materials, which will be updated in the future to include HAV technologies.

Recommendations for Jurisdictions

5.4.1. Provide training to driver license examiners on vehicle technologies, including the operation of HAVs.

- **Driver Education and Private Instructors**

  Driver education instructors can play a key role in educating consumers on HAV functions. Additionally, driver education materials will need to be updated to include information on the use and interaction of HAVs and for programs to provide hands on training in the use of HAVs.

  Standards for curricula and instructor training will need to be developed and updated on a regular basis as HAV technologies continue to evolve. Such standards may be available through the Novice Teen Driver Education and Training Administrative Standards (NTDETAS) on the ANSTSE website of which AAMVA is a participant. ANSTSE develops and maintains these national driver education standards.

Recommendations for Jurisdictions

5.4.2. Require driver education curricula to contain information on HAVs and to provide hands-on training in the use of HAV technologies.

5.4.3. Establish standards for the conduct and training of driver educators and private instructors for the training of drivers on the use of HAVs.

Benefits of Implementation

Training for driver license examiners will ensure they are familiar with HAV technologies. Standardization of content in driver education curricula and training for driver education instructors will ensure consistent information on automated vehicle technologies is delivered to new and experienced drivers.

Challenges to Implementation

There are inconsistencies among jurisdictions on standardized curricula content and instructor training standards. Some MVA staff and some driver license examiners have not received sufficient training on new vehicle technologies and the impacts it has on driver education and testing.

Educating the driving public on the safety and services that HAV technology provides will be critical to public acceptance of Level 4 and 5 vehicles and the idea that a vehicle user need not be a driver.

5.5 Driver License Skills Testing with Automated Vehicle Technologies

Background

Although most of this report addresses SAE International Level 3 to 5 vehicles, technology in Level 2 to 5 vehicles has implications for the driver license testing process. This includes a determination of what technologies are permitted during the driver

testing procedures. These technologies can be grouped into the following categories:

- **Convenience technologies** – for purposes of this report are technologies that provide conveniences for the driver (e.g., parking assist feature or auto-cruise control) and do not require the applicant to demonstrate a required skill set.
- **Safety critical technologies** – for purposes of this report are technologies that may prevent or reduce the severity of a crash. These technologies (e.g., backup or other cameras, alerts, lane departure warning, emergency braking assist) should be permissible and not be disengaged for testing.

Guidelines for Deployed Vehicles

The purpose of the driver license skills test is to determine an applicant's proficiency in operating a motor vehicle in most road situations. The applicant should not be assisted by vehicle convenience technologies. Skills testing evaluates the applicant's abilities, not the vehicle's technology.

Applicants should only use a vehicle that requires them to exhibit proper driving behaviors (driven in manual mode) and proficiency in operating a motor vehicle. Even though a vehicle has technology features, the applicant must demonstrate the ability to operate the vehicle in case the technologies require the driver to engage them manually or they become inoperable.

As technologies evolve, there may be a need to test drivers on their ability to operate specific vehicle technologies. Guidance in this area will be considered in future iterations of this report.

Some technologies cannot be disengaged and should be permissible during the testing process (e.g., lane departure warnings). The applicant should demonstrate proper responses to the technologies.

The use of safety critical technologies for off-road skills tests or parking maneuvers during the road test should be permitted. These technologies, such as backup or other cameras, should not be disengaged for off-road testing. NHTSA and Transport Canada will require all new vehicles produced after May 2018 to have rearview video systems also known as backup cameras.

The off-road skills test or parking during the road test should be revised to incorporate these technologies. In the case of backup cameras or other cameras, the criteria for checking mirrors and blind spots should be updated to evaluate the applicant's behavior to use cameras in conjunction with mirrors and head-checks, as an example.

The use of safety critical technologies should be permitted during the road skills test. In some cases, safety critical technologies cannot be deactivated. Safety critical technologies include, but are not limited to:

- Cameras;
- Blind spot warnings;
- Lane departure warnings; and
- Emergency brake assist

The road test scoring standards should be updated to reflect the proper procedures for examiners to follow when a safety critical function activates during the testing process.

A licensed driver is required for Level 3 vehicles because the technology has the ability to switch from an automated mode to a manual mode, allowing the driver to operate the vehicle. In this situation, the driver would be required to perform the examination in manual mode to ensure they can safely operate the vehicle.

Driver testing and thus a driver license should be required for any person sitting in the driver's seat of

a vehicle with Level 3 or lower functionality because they should be expected to take control of the vehicle at any time. A person should not be required to have a driver's license for Level 4 and 5 vehicles if there are no driver controls (e.g., steering wheel).

MVA driver manuals do not currently contain information on ADS technologies. These manuals will need to be updated to include pertinent information on HAVs.

AAMVA plays a major role in assisting jurisdictions with driver testing practices and driver license examiner training. The AAMVA TMS is responsible for maintaining and updating AAMVA's model driver testing systems, including the AAMVA Noncommercial Model Driver Testing System (NMDTS).

Recommendations for Jurisdictions

5.5.1. Include information on vehicle technologies and ADS in the jurisdiction's driver's manual, when provided by the AAMVA TMS.

5.5.2. Include questions addressing ADS in the jurisdictional knowledge test, when provided by the AAMVA TMS.

5.5.3. Jurisdictions should not allow the applicant to use convenience technologies, such as the parking assist feature, for off-road skills tests or parking maneuvers during the road test. The applicant should be required to demonstrate the ability to park the vehicle.

5.5.4. Allow the applicant to utilize safety critical technologies for skills tests or parking maneuvers during the road test. These technologies, such as backup or other cameras, should not be disengaged for off-road testing.

5.5.5. Jurisdictions should not require applicants to deactivate safety critical technologies during the testing process.

Benefits of Implementation

Standardized testing procedures and driver's manual information will ensure consistent driver testing practices for ADS technologies. AAMVA's NMDTS and the AAMVA TMS may facilitate this standardization.

Challenges to Implementation

Agreement among jurisdictions on standardized procedures for testing drivers in vehicles with technologies will be essential to achieve consistency. Additionally, agreement on standardized information to be included in jurisdictional driver manuals on the operation of vehicle technologies will be a challenge.

With the technology benefits of Level 4 and 5 vehicles, those who cannot obtain a license to drive will have the ability to be transported by Level 4 and 5 vehicles. However, if the manufacturer provides the user the technical ability to switch to a manual drive mode, individuals will be placed in an unsafe situation if the user of the vehicle could not legally obtain a driving privilege under normal circumstances. There may be some resistance to requiring a driver's license for Level 4 and 5 vehicles with manual driver controls, and jurisdictions may have difficulty determining when skills testing is required, considering the numerous makes and models of HAVs.

5.6 Endorsements and Restrictions for Deployed Vehicles

Background

Because the driver of Level 0-3 vehicles is expected to be in control of the vehicle, most current driver license qualifications will apply to their operation. Therefore, existing driver license qualifications will remain applicable.

Vehicles with Level 4 and 5 functionality have the expectation of enhancing the mobility of those unable to drive or to be licensed because of physical

disability, age, or some other condition. Permitting passengers without a licensed driver in these vehicles while the ADS is performing the DDT within its ODD would allow these populations to reap the benefits of the technology. Level 4 and 5 vehicles may not have a driver or passengers (e.g., empty vehicle or cargo).

Guidelines for Endorsements and Restrictions

The full implication of endorsements or restrictions for HAVs is not yet fully understood, particularly for Level 4 and 5 vehicles. Until these technologies have completely developed, driver license endorsements and restrictions are not recommended.

Additionally, there is a risk of creating conflicting jurisdictional endorsements and restrictions if jurisdictions consider this licensure regime. This will complicate the exchange of driver's licenses from jurisdiction to jurisdiction in translating codes. AAMVA and the U.S. DOT will need to examine the development of standardized codes for endorsements and restrictions if they are warranted.

Jurisdictions should not impose any other requirements, such as licensure, sobriety, clean driving history, and so on, for nondrivers to be passengers in Level 4 and 5 vehicles if the vehicle cannot be operated in manual mode. Assuming Level 4 and 5 vehicles will require the passenger only to provide destination or navigation input, no special training or qualification should be required. The operation of Level 4 and 5 vehicles is comparable to taking a taxi, riding a bus, or riding the subway, none of which requires special training or licensure.

There is the potential for unsupervised children to be placed in HAVs. Jurisdictions will need to review their laws and regulations related to unsupervised children in motor vehicles and adopt appropriate laws and regulations to ensure safety.

Recommendations for Jurisdictions

5.6.1. Jurisdictions should not establish endorsements or restrictions on driver licenses at this time.

5.6.2. Take steps to ensure jurisdictional motor vehicle laws allow for the operation of Level 4 and 5 vehicles without a driver if the vehicle cannot be operated in manual mode.

5.6.3. Jurisdictions should not limit the operation of Level 4 and 5 vehicles to individuals who are licensed as drivers.

5.6.4. Jurisdictions should not impose any other requirements, such as licensure, sobriety, clean driving history, and so on, for nondrivers to use Level 4 and 5 vehicles.

5.6.5. Take steps to ensure a licensed driver is prepared and capable of taking control of the vehicle if the vehicle has a DDT manual fallback.

5.6.6. Review jurisdictional laws and regulations related to unsupervised children in motor vehicles and adopt appropriate laws and regulations to ensure safety.

Benefits of Implementation

Conflicting jurisdictional HAV codes and the complications in translating codes when exchanging driver licenses from jurisdiction to jurisdiction is eliminated by not creating HAV endorsements and restrictions.

Challenges to Implementation

If a jurisdiction implements HAV endorsements and restrictions, it will create challenges for other jurisdictions for the exchange of driving privileges.

Chapter 6 Law Enforcement Considerations

6.1 Crash and Incident Reporting

Background

For the purposes of this guidance, crash reporting should occur when there are crashes or incidents between HAVs and other vehicles, persons, animals, or objects whether or not the HAV is responsible.

Safety and crash avoidance are priorities of all automobile manufacturers. But regardless of the level of safety engineering, crashes are inevitable during testing and deployment on public roads. Crash and incident reporting are important for purposes of identifying and documenting safety concerns and establishing liability. Crash report information is not only of importance to manufacturers and the engineering community but also to a variety of public constituencies, including regulators and legislators. Full disclosure of information concerning how a crash occurred and why it occurred will be essential to future development, regulation, and public acceptance of HAVs.

Guidelines for Testing Vehicles

HAV manufacturers or other entities should submit to the jurisdiction incident- and crash-related information to expand HAV data and research as needed by the jurisdiction. The information should include instances of a crash when HAVs are operating in automated mode or disengaged (by the user or by the system). The information should also include incidents in which the users of HAVs are unexpectedly prompted to transition into manual mode because of a failure of the automated system. Manufacturers and other entities should be required to submit a summary analysis of the incident.

Requiring manufacturers or other entities to report unexpected incident failures and crashes to the jurisdiction provides transparency between agencies and manufacturers or other entities throughout the testing phase. Sharing this data and their analysis of the incident would be beneficial to jurisdictional policymakers.

When an HAV is involved in a crash, the information obtained from the HAVs recorded data could prove important to determining whether or not an HAV malfunction caused the crash or if the crash could otherwise have been avoided. Additionally, the data collected from the vehicle(s) involved could potentially provide insight into how the HAV reacts to given scenarios. The data recorded should include, but not be limited to, the mode of operation (autonomous vs. manual control), speed, throttle or brake application, and a 360-degree video sample of the vehicle surroundings if so designed or equipped. Law enforcement should be provided with access to this information as well as a minimum of 30-seconds pre-crash and post-crash data for completing a proper investigation.

Recommendations for Jurisdictions

6.1.1. Require HAV manufacturers to submit to the jurisdiction crash-related information and a summary of the manufacturer's analysis of the incident to expand the amount of HAV data and research.

Guidelines for Deployed Vehicles

The U.S. DOT Model Minimum Uniform Crash Criteria (MMUCC), 5th edition (August 2017) includes guidance for capturing automated vehicle data on crash reports to assist in crash causation determination and support further automated vehicle development and safety. U.S. jurisdictions will need to adopt the MMUCC recommendation as soon as practicable.

Large amounts of data are captured by the vehicle event data recorder (EDR). In certain instances, the EDR information would aid a crash investigation by revealing pre-and post-crash causative factors and actions. This information may include both the driver and automated system actions when the users of automated vehicles are prompted to transition into manual mode because of a failure or dysfunction of the automated system.

Manufacturers should ensure HAVs record vehicle behavior sensor data and the driver–vehicle interface and should also include time stamping and Global Positioning System (GPS) location in the EDR data. In addition, to ensure effective crash investigation and safety analysis, manufacturers should make EDR information retrievable in a standard, nonproprietary format for ready access by those duly authorized in accordance with laws protecting data privacy.

Recommendations for Jurisdictions

6.1.2. U.S. jurisdictions should adopt the MMUCC 5th edition (August 2017) recommendation as soon as practicable.

Recommendations to Manufacturers and Other Entities

MOE 6. Manufacturers should design HAVs to record vehicle behavior sensor data and the driver–vehicle interface. Law enforcement should be provided with access to this information as well as a minimum of 30-seconds pre-crash and post-crash data for completing a proper investigation.

MOE 7. Manufacturers should make EDR information retrievable in a standard, nonproprietary format for ready access by those duly authorized.

MOE 8. Manufacturers should include time stamping and GPS location in EDR data.

Benefits of Implementation

Collection of crash and incident data would be beneficial to manufacturers and developers during the developmental process. Once deployed, in addition to manufacturers and developers, law enforcement and other applicable agencies would also benefit from data samples provided in the event of a crash to aid in determining fault and vital pre-crash data.

Challenges to Implementation

Because much of the HAV industry is proprietary, manufacturers may object to part or all of this recommended guideline.

6.2 Criminal Activity

Background

There are both substantial opportunities and risks presented by automated driving that will increase the tactical performance of physical tasks over a person driving a car manually. Automated vehicles have the potential to improve driving safety and make mobility more efficient. However, they will also create greater possibilities for dual use applications and ways for a vehicle to be used to further criminal enterprises—or worse, be used as a tool for the delivery of explosives or other means of causing harm. This is not only a clear and present danger but also further complicates any subsequent criminal investigation.

New technologies that will be available in Level 5 vehicles present opportunities to prevent certain vehicle-related crimes from being committed and in assisting law enforcement in interdicting crimes. They

also present an opportunity to aid in the investigation of crimes that have been committed.

Although Level 5 vehicles will substantially reduce the risk of in-vehicle distractions leading to crashes, criminals will also be able to conduct tasks that require use of both hands or to take one's eyes off the road. Aiming and firing a weapon at a pursuing patrol vehicle is the most obvious example of a multi-tasking threat.

Guidelines for Testing Vehicles

Before authorization to operate a test vehicle, the employees, contractors, and other persons designated by the manufacturer or other entities should be required to pass a background check including, but not limited to, a driver history review and a criminal history check. In the interest of safety, it may be prudent to disqualify persons with poor driving records or criminal records from operating an HAV as an agent or contractor of a manufacturer or other entity in a test environment.

Recommendations for Jurisdictions

6.2.1. Jurisdictions that have HAV permitting requirements as described in Section 4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways should require the designated test users (employees, contractors, and other persons) to pass a background check including, but not limited to, a driver history review and a criminal history check, before authorization to operate a test HAV.

6.2.2. Jurisdictions that have HAV permitting requirements as described in Section 4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways should establish provisions which disqualify an agent or contractor of a manufacturer or other entity who have criminal records or a driving history that includes DUI, reckless driving, or other significant conviction history from operating an HAV in a test environment.

Recommendations for Manufacturers and Other Entities

MOE 9. The manufacturer or other entity, operating in jurisdictions not requiring HAV permits, should require the designated test users (employees, contractors, and other persons) to pass a background check, including, but not limited to, a driver history review and a criminal history check, before authorization to operate a test HAV.

MOE 10. The manufacturer or other entity, operating in jurisdictions not requiring HAV permits, should disqualify an agent or contractor of a manufacturer or other entity who have criminal records or poor driving history from operating an HAV in a test environment.

Guidelines for Deployed Vehicles

It should also be noted that Level 5 vehicles may also be a target for criminal activity, such as car-jacking, because they may not be capable of intuitive reaction or evasive maneuvers as a human user could use.

To assist law enforcement in investigating criminal activity in which a vehicle with automation was implicitly involved as a tool for committing a crime, manufacturers should ensure HAVs leave an electronic fingerprint that can allow tracing of input data.

Recommendations for Manufacturers and Other Entities

MOE 11. Manufacturers should ensure HAVs leave an electronic fingerprint that can allow tracing of input data to whoever initiated them.

Benefits of Implementation

Requiring manufacturers to program software that leaves an electronic fingerprint will mitigate the risk of an automated vehicle being used as a tool to assist in the commission of, or escape from, a crime.

Challenges to Implementation

Legislative action or administrative rule making will be required to implement the recommended guideline.

6.3 Distracted Driving

Background

The potential for reducing or eliminating distracted driving is a common topic when discussing HAVs. The term "distraction" as used by NHTSA is a specific type of inattention that occurs when drivers divert their attention away from the driving task to focus on another activity. These distracting tasks can affect drivers in different ways and can be categorized into the following types:

Visual distraction: Tasks that require the driver to look away from the roadway to visually obtain information

Manual distraction: Tasks that require the driver to take hand(s) off the steering wheel to manipulate a device or other distracting activity

Cognitive distraction: Tasks that are defined as the mental workload associated with a task that involves thinking about something other than the driving task

The impact of distractions on driving is determined not just by the type of distraction but also the frequency and duration of the task. Because drivers often have a choice regarding when and how often to multitask when driving, their exposure to risk is typically within their control; however, some research has shown that drivers underestimate the overall risk of various tasks.[1]

Guidelines for Testing Vehicles

When testing any HAV, the user is an active participant in the testing process; therefore, all distracting activities should be prohibited.

Recommendations for Manufacturers or Other Entities

MOE 12. Manufacturers or other entities should prohibit users from all distracting activities when testing any HAV.

Guidelines for Deployed Vehicles

Jurisdictions should consider at what level of autonomy their distracted driving laws continue to apply. When a vehicle is in automated mode, the user may still need to maintain a level of awareness in case they need to re-engage with the driving function if prompted by the vehicle. Because the operation of some HAVs may require no participation by the driver, distracting activities may not be relevant, or distracted driving laws may not apply. Manufacturers should design HAVs with a means of identifying when a vehicle is in automated mode to facilitate effective enforcement of distracted driving laws (i.e., so an officer knows if using a hand-held device is legal at the time of observation).

Recommendations for Jurisdictions

6.3.1. Consider the level of automation to which their distracted driving laws will apply.

Recommendations for Manufacturers or Other Entities

MOE 13. Manufacturers or other entities should design HAVs with a means of identifying when a vehicle is in automated mode to

1 Overview of the National Highway Traffic Safety Administration's Driver Distraction Program, DOT HS 811 299, April 2010.

facilitate effective enforcement of distracted driving laws (i.e., so an officer knows if using a hand-held device is legal at the time of observation).

Benefit of Implementation

A reduction in crashes caused by driver distraction.

Challenges to Implementation

Many jurisdictions have laws prohibiting the use of an electronic device while driving. A challenge to law enforcement officers will be knowing the level of the HAV and what mode the vehicle is in when they observe a user interacting with an electronic device.

6.4 Enforcement of Permit Conditions

Background

Jurisdictions may establish a permitting process as described in Section 4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways to promote safety in the testing of automated vehicle technologies on public roads. For example, jurisdictions may require that test drivers meet certain qualifications or prohibit testing in work zones or school zones. Although provisions of the permitting process may vary significantly among jurisdictions, public trust and the integrity of the permitting process require a means to enforce any conditions imposed on the testing entity.

Guidelines for Testing Vehicles

An internal jurisdictional process should be developed that includes an application for manufacturers to test on public roadways within the jurisdiction. This internal process should include provisions for suspension or revocation of any permit to test on public roads should permit holders violate permit conditions. The jurisdictions should also consider the imposition of penalties if the testing entity continues to operate or test in violation of that suspension or revocation order. Test users should be held responsible for violations of existing traffic laws subject to existing legal processes.

Recommendations for Jurisdictions

6.4.1. Develop an internal process that includes an application for manufacturers to test on public roadways within the jurisdiction and include provisions for suspension or revocation of any permit to test on public roads if permit holders violate permit conditions.

6.4.2. Consider the imposition of penalties if the testing entity continues to operate or test in violation of a suspension or revocation order.

6.4.3. Hold test users responsible for violations of existing traffic laws subject to existing legal processes.

Guidelines for Deployed Vehicles

It is expected that regulations developed to ensure safety during testing would not be applicable to deployed vehicles because these vehicles will have been adequately tested, evaluated, and certified for safety and compliance with FMVSS or CMVSS.

Recommendations for Jurisdictions

6.4.4. Jurisdictions should not use regulations developed for testing for deployed vehicles because these vehicles will have been adequately tested, evaluated, and certified for safety and compliance with FMVSS or CMVSS.

Benefits of Implementation

By enforcing permit compliance, public safety and the integrity of the permitting process are improved. The purpose of the permitting process is to ensure safety during development. But issuing a permit alone

does not ensure safety if a permit holder is not held accountable to the conditions of the permit (i.e., background checks, operating in school zones). There must be ramifications for violating the conditions of the permit to ensure integrity in the testing process.

Challenges to Implementation

Manufacturers may view any permitting process as an impediment to their ability to test and develop HAV technology. Jurisdictions may lack the resources to monitor and enforce provisions of its permitting process.

6.5 Establishing Operational Responsibility and Law Enforcement Implications

Background

Jurisdictions have legal authority to regulate vehicle operation by humans but may not have established authority over non-human operation. This void presents significant challenges to enforcement of traffic laws and to establishing legal responsibility when Level 3 to 5 vehicles are involved in motor vehicle crashes on public roads. Jurisdictions will need to address the following issues:

- Is the driver of a vehicle with automated features engaged still responsible for the operation of that vehicle even if they are not performing the DDT?
- In such instances, how will law enforcement officers know when the human is actively driving or the "driving system" is in control?

Although this may appear to be less of an issue as vehicle technologies approach Level 5, from an enforcement perspective, the issue is still confounding because many jurisdictions lack any procedural enforcement mechanism against any entity other than the human driver operating the vehicle at the time of the offense or crash. Traffic tickets or violation notices usually cannot be issued to registered owners or corporate entities, and with the exception of parked vehicles, crash reports require a human driver for each involved vehicle. This may not apply to automated enforcement. Jurisdictions may need to define what enforcement actions can be taken and who or what is responsible when there is no human on board.

Guidelines for Testing Vehicles

Jurisdictions will need to clearly establish legal responsibility for every vehicle operating on public roads. If a licensed driver is required to be on board the vehicle during testing, that driver is responsible for the safe operation of the vehicle at all times and should be accountable for any violations of law and be considered the "driver" of the vehicle regardless of her or his degree of actual control of the DDT.

When Level 4 and 5 vehicles, with or without a human on board, are tested on public roads, the permitting process, described in Section 4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways should clearly identify the person or entity legally responsible for the safe operation of the vehicle at all times. Before any testing permits are issued, the legal mechanism and authority to hold the responsible entity accountable for violations of laws and crashes that may occur during testing should be clearly established in statute.

Recommendations for Jurisdictions

6.5.1. Define what enforcement actions can be taken and who or what is responsible when there is no human on board an automated test vehicle.

Guidelines for Deployed Vehicles

Legal responsibility for every vehicle operated on public roads should be clearly established. Currently, the licensed drivers of Level 0 to 2 vehicles are

responsible for its safe operation at all times and are held legally responsible for any violation of law that may occur during operation. The same should be the case with Level 3 vehicles. Although the licensed driver of a Level 3 vehicle may cede control of the DDT to the vehicle under certain circumstances or driving conditions, such vehicle by definition still requires the driver to monitor the DDT and to take control as necessary. A licensed driver, therefore, is still responsible for the safe operation and liable for violations of law during operation.

Vehicles classified as Level 4 or 5, which may be operated without a licensed driver on board and when the DDT may be performed independent of human control, new statutes or regulations may be required to establish similar responsibility and liability for violations of traffic laws. Registered owners of such vehicles should be responsible for properly maintaining all vehicle equipment and systems, including, but not limited to, the prompt completion of any required updates impacting its operation. Therefore, registered owners of such vehicles, as the agents of the operation of such vehicles on public roads, should be responsible for their adherence to applicable laws and subject to legal process as determined by the jurisdiction. Product liability issues arising from such cases may be matters of civil process ex post facto but should not impact the enforcement of laws contemporaneously with operation.

Recommendations for Jurisdictions

6.5.2. Clearly establish legal responsibility for every vehicle operating on public roads.

6.5.3. For vehicles classified as Levels 4 or 5, which may be operated without a licensed driver and when the driverless vehicle performs the DDT independent of human input, the registered owner should be responsible for its safe operation.

Benefits of Implementation

These guidelines ensure there is a clearly identified party who is legally responsible for the operation of all vehicles at all times and provides law enforcement with a mechanism to enforce traffic safety laws. This will provide clarity to manufacturers, technology developers, law enforcement officers, and vehicle owners of legal responsibility for vehicles of varying automated capabilities.

Challenges to Implementation

The insurance industry may oppose holding registered owners responsible for the operation of the vehicle as opposed to the manufacturer or technology upfitter. Industry may oppose these guidelines as unnecessary regulation that may hinder development and public acceptance of technology adoption.

6.6 First Responder Safety

Background

Although HAVs may provide significant safety benefits by reducing human errors, they will inevitably be involved in traffic crashes, especially during the years of initial introduction and integration with the existing motoring population. Because of the potential for unique operational characteristics of HAVs, responders to these crashes may be placed at risk if they are not trained for the hazards they may encounter. These hazards include, but may not be limited to:

- silent operation,
- self-initiated or remote ignition,
- high voltage, and
- unexpected movement.

In the interest of safety, it is essential that first responders, including those in police, fire, emergency medical services (EMS), and tow and recovery

services, receive information regarding the potential hazards they may face.

The National Fire Protection Association (NFPA) developed training programs for both fire service and law enforcement to safely respond to crashes involving electric and hybrid electric vehicles. NFPA also provides ongoing training for the fire service on hazards involving a variety of alternative fuel vehicles. The training focuses on three main functions to render the vehicles safe:

- the ability of the responder to identify the vehicle (and its propulsion system),
- immobilize it, and
- permanently disable it.

Identification of the vehicle at a safe distance is essential and best accomplished through manufacturer labeling (also known as badging) and familiarity with component designs, such as high-voltage orange cabling. Immobilization involves knowing how to place the vehicle transmission in park; set parking brakes; and if appropriate, chock the wheels to restrict movement. Disabling techniques involve ensuring the vehicle is turned off; removing potential reignition sources, such as proximity keys, from the vicinity of the vehicle; and cutting 12-volt power supplies to prevent ignition and depower airbags and seat belt tensioners.

Some or all of these procedures may be applicable to varying degrees to automated vehicles. The importance of labeling to assist in vehicle identification is discussed at length in Section 6.10 Vehicle Identification. Identification strategies that are integrated into the vehicle design will likely be most effective, rather than post-manufacture strategies, such as license plates that lack redundancies and can easily be removed or obscured in a crash. Immobilization and disabling issues may be unique to automated vehicles, which have the potential for remote or self-initiation of ignition or movement. Immobilizing and disabling automated vehicles may require switches or components designed specifically for this purpose, and these functions should be considered in the development of vehicle systems by the OEMs.

Although NFPA training is provided to most fire services in the U.S., information has not been well distributed to law enforcement and other responders, resulting in significant vulnerabilities. First responder safety information specific to automated vehicles should be identified and disseminated before public use or deployment.

Guidelines for Testing Vehicles

Because the test environment of HAVs includes public roadways, there will be crashes involving HAVs that may put first responders or the general public at risk. For the safety of first responders, manufacturers should permanently label HAVs that will be tested on public roadways, at a minimum, on the rear and sides of the vehicle. For the safety of vehicle occupants and first responders, manufacturers should ensure HAVs have safety systems or procedures that allow first responders to immobilize or otherwise disable the vehicle post-crash to prevent movement or subsequent ignition of the vehicle. Information regarding these systems and procedures should be made available to the first responder community in the jurisdiction where the vehicle will be operated.

Guidelines for Deployed Vehicles

For the safety of first responders, manufacturers should permanently label HAVs, at a minimum, on the rear and sides of the vehicle. For the safety of vehicle occupants and first responders, manufacturers should ensure HAVs have safety systems or procedures that allow first responders to immobilize or otherwise disable the vehicle post-crash, to prevent movement or subsequent ignition of the vehicle. Information regarding these systems and procedures should be made available to the first responder

community in the jurisdiction where the vehicle will be operated.

Recommendations to Manufacturers and Other Entities

MOE 14. Manufacturers should ensure HAVs are permanently labeled, at a minimum, on the rear and sides of the vehicle for the safety of first responders.

MOE 15. Manufacturers should ensure HAVs have safety systems or procedures that allow first responders to immobilize or otherwise disable the vehicle post-crash to prevent movement or subsequent ignition of the vehicle for the safety of vehicle occupants and first responders.

MOE 16. Manufacturers should make the information regarding HAVs and procedures available to the first responder community in the jurisdiction where the vehicle will be operated.

Benefits of Implementation

Accurate identification of HAVs at crash scenes prevents unnecessary injuries or deaths of emergency personnel who respond to crash scenes and the public at large involved in or near crash scenes.

Challenges to Implementation

Vehicle labeling is linked to brand and has been traditionally considered highly proprietary. OEMs may oppose any regulation they perceive impacts the aesthetics of their product.

OEMs may be reluctant to disclose any information relative to vehicles under development, which places the public and first responders at risk if test vehicles are involved in crashes.

6.7 Law Enforcement and First Responder Training

Background

It is important for first responders and law enforcement specifically to understand how HAVs impact their duties, so there is a growing need for training and education. Training content needs to be identified, and officers will need training for safely interacting with vehicles and users in both the testing and deployment of HAVs.

Guidelines for Testing Vehicles

Training law enforcement personnel based on jurisdictional laws and regulations is essential. This training will likely differ during the phase of HAV testing from when they are deployed because of regulations and laws which may be enacted. When training and educational tools become available, they should be disseminated through jurisdiction-level established training bodies. The use of approved training materials allows for uniformity across jurisdictions and their law enforcement agencies. Training should be updated as laws and rules change or when manufacturers make design changes. Primary stakeholders to develop and disseminate training may include associations such as AAMVA, NFPA, and the International Association of Chiefs of Police (IACP).

Guidelines for Deployed Vehicles

The first responder audience needs access to HAV training. National or international standardized first responder training on safely interacting with vehicles and users in both the testing and deployment of HAVs should be developed. Jurisdictions should work with manufacturer's consumer training programs to make training available to first responders at no cost to agencies.

Recommendations for Jurisdictions

6.7.1. Work with manufacturers' consumer training programs to make HAV training available to first responders at no cost to agencies.

Recommendations for Manufacturers and Other Entities

MOE 17. Manufacturers, in partnership with highway safety stakeholders, should develop national or international standardized first responder training on safely interacting with vehicles and users in both the testing and deployment of HAVs.

Benefits of Implementation

Standardized training will enhance the safety of first responders and the public they serve.

Challenges to Implementation

Uncertainty of training content that should be included in law enforcement training curricula is exacerbated by the lack of a national standard. Another challenge will be keeping training current as the technology continues to evolve.

6.8 Vehicle Response to Emergency Vehicles, Manual Traffic Controls, and Atypical Road Conditions

Background

Traffic safety is often dependent on the ability of a driver to recognize and respond appropriately to a wide variety of hazards in an ever-changing roadway environment. These hazards include but are not limited to:

- both moving and stopped emergency vehicles;
- emergency workers and other pedestrians manually directing traffic;
- changing traffic patterns or conditions in roadway construction and maintenance zones;
- crash scenes; and
- road debris or other obstructions.

Object and event detection and response (OEDR) refers to the detection by the driver or HAV system of any circumstance that is relevant to the immediate driving task, as well as the implementation of the appropriate driver or system response to such circumstance.

Guidelines for Testing and Deployment

Manufacturers should ensure that vehicles operated on public roads, both during testing and deployment, be able to recognize and properly respond to all temporary traffic controls and atypical hazards in the roadway environment. Temporary traffic controls include cone or flare patterns as well as human hand directions and flagging. In addition, vehicles should properly identify, differentiate, and respond to both moving and stopped emergency vehicles and hazard vehicles, such as road maintenance vehicles bearing amber lights. Proper responses should include compliance with move-over-laws.

Recommendations for Manufacturers and Other Entities

MOE 18. Manufacturers should ensure that vehicles operated on public roads, both during testing and deployment, be able to recognize and properly respond to all temporary traffic controls and atypical hazards in the roadway environment.

Benefits of Implementation

Vehicles that adequately respond to changing road conditions will increase safety of first responders, roadway workers, and the public.

Challenges to Implementation

It may not be practicable to replicate every possible road restriction or hazard that may be encountered during HAV testing in the real world, and under extraordinary circumstances, it may be necessary to violate laws or rules of the road to safely navigate some hazards safely (e.g., driving on shoulders or disobeying lane markings or signs). In addition, manual traffic control gestures are not universally consistent and may be performed by professionals or non-professionals alike. Move-over and other traffic laws are not currently uniform among jurisdictions, and adherence to these laws may require geographic awareness.

6.9 System Misuse and Abuse

Background

Misuse of an automated vehicle system may be defined as operating automated features improperly or inappropriately, such as failure to take affirmative control of a vehicle when directed to do so by the automated system. Issues of misuse may be linked to proper training and credentialing but also have a major role in determining crash causation, which distinguishes fault and criminal or civil liability. Law enforcement has the responsibility of determining crash causation whenever possible, but partial or complete automation may make these determinations more difficult to discern from traditional human user errors.

Abuse of an automated vehicle system may be defined as the intentional or malicious use of HAV capabilities for some unlawful purpose. Issues of abuse (or intentional misuse as defined above) will likely involve criminal behavior and may have vast implications on public safety. Examples of abuse range from criminal transportation, such as drug running, to cybersecurity breaches or terrorism. Strategies to address both misuse and abuse must consider the myriad of ways to perpetrate each.

One issue is whether new laws or regulations are necessary to deter these behaviors or to assist law enforcement in performance of their duties in prevention or after an incident. The elements of law violations inherent to misuse or abuse already exist, whether or not vehicle technology was used in the violation of law. For example, a speeding violation is still a speeding violation whether or not cruise control was active at the time of the offense, and vehicles are widely used in the commission of crimes or to transport goods or proceeds of crimes today. In some foreseeable instances, such as vehicular assault or homicide, culpability may be an issue.

Crash and criminal investigation would be greatly aided by electronic records of the vehicle and human interface. FMVSS codified in 49 CFR/Part 563 currently specifies that certain information be recorded by vehicle EDRs, but the data stored may be inadequate for the forensic need in determining misuse or abuse. In addition to the EDR, the vehicle central processing unit (CPU) stores data not resident in the EDR and may also need to be accessed, under certain circumstances, by law enforcement. Lack of standardization of data in a nonproprietary format hinders its usefulness for law enforcement or public safety purposes.

Guidelines for Testing Vehicles

It could be assumed that it is far less likely that misuse or abuse would occur in a test environment where users are intimately familiar with the vehicle capabilities and use is highly controlled, recorded, and researched. Nonetheless, because extensive testing occurs on public roads, the public interest demands that researchers and developers record the behavior of the vehicle and the driver–vehicle interface at all times during operation.

Recommendations for Manufacturers or Other Entities

MOE 19. Manufacturers or other entities, such as researchers and developers, should record the behavior of the vehicle and the driver–vehicle interface at all times during operation.

Guidelines for Deployed Vehicles

Manufacturers should design HAVs to record both vehicle behavior and the driver–vehicle interface to identify the actions of the vehicle and the actions (or lack thereof) by the driver at all times. This recording mechanism should include GPS and time information to allow investigators to ascertain what occurred, where and when. Precedent is currently established for standardization of data recording in 49 CFR 563 (FMVSS) relative to EDR information, but this information is not time or geo-stamped and is only triggered by the airbag module when the airbag is deployed.

The EDR and CPU information should be stored and retrievable in some recognized, standard, nonproprietary format for ready access by those duly authorized.

Recommendations for Manufactures and Other Entities

MOE 20. Manufacturers should design HAVs to record both vehicle behavior and the driver–vehicle interface to identify the actions of the vehicle and the actions (or lack thereof) by the driver at all times.

MOE 21. Manufacturers should ensure the EDR and CPU information that accomplishes *Recommendation MOE 20* is stored and retrievable in some recognized, standard, nonproprietary, format for ready access by those duly authorized.

Benefits of Implementation

These recommendations will assist law enforcement in determining crash causation and criminal investigation, including, but not limited to, whether system misuse or abuse were involved by providing behavioral information and vehicle performance information in the most serious cases. Users of HAVs may be deterred from engaging in misuse or abuse knowing their behaviors are recorded by the vehicle and that information is accessible by law enforcement or others duly authorized.

Challenges to Implementation

Such requirements may be perceived as an unwarranted overreach of governmental authority. EDRs have operated and stored data in proprietary formats for proprietary purposes. Manufacturers can be expected to oppose requirements that dictate what information is captured and accessible to the authorized investigator.

6.10 Vehicle Identification

Background

Identification of a motor vehicle as an HAV is necessary for law enforcement officers and other first responders to fulfill their duties. These duties include ensuring that the user or driver is properly credentialed (if required), ensuring the safety at the scene if the user or driver is incapacitated in a crash and aids in the recovery of a stolen vehicle.

From a law enforcement perspective, license plates alone may not be the optimal means to identify the vehicle as an HAV because license plates are susceptible to theft. License plates only allow identification from the rear in one plate jurisdictions, and because most crashes involve front or rear damage, will frequently be obscured. In addition, many jurisdictions currently issue a vast array of unique plate designs; one more plate design will not

likely improve identification of the vehicle if a similar model vehicle exists in the marketplace.

In contrast, vehicle labeling or permanent marking to identify the vehicle as an HAV allows for redundant marking in multiple locations (exterior and interior), improving conspicuity from multiple vantage points. SAE, International Organization for Standardization (ISO), and NHTSA all have developed labeling guidelines or have issued proposed rules for labeling of alternative fuel vehicles. Although these guidelines, or in the case of NHTSA, a proposed rule, have varied purposes, they may provide some guidance for accepted labeling practices.

SAE and ISO provide guidance for OEMs relative to first and second responder safety for vehicle crashes involving electric and hydrogen-fueled vehicles (xEVs) and includes reference to labeling to assist emergency responders to identify the drive system of the vehicle at a safe distance. This is important because many of these vehicles have virtually silent motors or drive systems that can result in unexpected vehicle movements. Although the SAE recommended practices (J2990 and J2990/1) and ISO recognized symbol usage are nonbinding, they already have a certain level of acceptance among the OEMs. However, to date, no unique symbols or identification for automated vehicles have been standardized by either organization.

ISO symbols are unique to the particular drive system (i.e., a different symbol for hybrid electric, plug in electric, hydrogen fuel cell). In contrast, SAE J2990 and 2990/1 provide consensus standards for a variety of labeling strategies and designs. By following J2990, OEMs may adopt the ISO symbols, but to date, few have done so. Vehicle drive systems may also be identified by badges indicating "hybrid" or a unique descriptive term, such as "CH2." Alternatively, J2990 and 2990/1 provide as an alternative that manufacturers may use a unique brand name, such as Chevrolet's "Volt" or Nissan's "Leaf," which are unique to a single type of drive system that will allow for easy identification by first responders.

Despite such labeling strategies developed to improve safety, OEMs may object to unique labeling to avoid jeopardizing earned customer loyalty by making these vehicles seem different or less reliable than a similar internal combustion model.

NHTSA issued a notice of proposed rulemaking (NPRM) in 2014 for labeling of alternative fuel vehicles, including, but not limited to, vehicles covered by the recommended practices of SAE and recommended symbols of ISO. In contrast to the safety intentions of the SAE and ISO recommended practices, NHTSA's proposed labeling strategy benefits consumer awareness regarding use and benefits of alternative fuels. The NPRM would require "permanent and prominent display" of the type of alternative fuel (nonpetroleum) that powers the vehicle in "natural language" (i.e., not symbols or brand-specific terminology). Although rulemaking has not progressed beyond the NPRM (closed April 21, 2014), it at least demonstrates that federal authority for vehicle labeling in the case of automated vehicles would not be unprecedented.

In addition to vehicle labeling, other vehicle identification strategies should be considered to improve safety and to facilitate motor vehicle administration and law enforcement. The VIN conveys significant information regarding the characteristics of the motor vehicle to which it is issued, and new VIN systems should be considered. VIN information should include information relative to HAV systems on board the vehicle. This information should be tied to registration and user credentialing. (Reference Section 4.2 regarding Vehicle Registration and Section 5.2 regarding Driver License Requirements.)

Guidelines for Testing Vehicles

Whenever an HAV is operated on a public road, it is susceptible to crash and theft. Therefore, an HAV should be readily identifiable from other vehicles

on the roadway for the safety of law enforcement and other first responders. The optimal means for accomplishing identification is through vehicle labeling by OEMs.

Because jurisdictions have authority over vehicle registration, a unique HAV identifier on the vehicle registration may provide an alternative, albeit less effective, means of identifying HAVs for law enforcement purposes during testing. However, because vehicle labeling will better identify these vehicles and thereby improve safety and regulatory control, manufacturers should ensure HAVs have permanent labeling on the rear and sides of the vehicle. Refer to *Recommendation MOE 14*.

Recommendations for Jurisdictions

6.10.1. Enact requirements for permanent labeling on the rear and sides of an HAV to better identify vehicles and improve safety and regulatory control.

Recommendations for Manufacturers and Other Entities

MOE 22. Manufactures should develop international consensus standards for a system of permanent labeling of HAVs to ensure consistency of safety information on vehicles with automated features.

Benefits of Implementation

These recommendations, if adopted, will allow law enforcement and other first and secondary responders to readily identify a vehicle as one with automated capability to ensure the safety of crash scenes, identify the credentialing necessary of users and owners, and aid in the recovery of stolen vehicles.

Challenges to Implementation

The labeling of vehicles has historically been the purview of vehicle manufacturers, which have significant interest in retaining the identity and integrity of their brand. OEMs may oppose efforts to standardize how the capability of their vehicles is conveyed to the motoring public. Historically, OEMs have named features in a proprietary manner to further distinguish their brand or model, or they have chosen not to differentiate model-specific features from other models in their lineup to signify equal levels of quality or reliability across the brand. Federal labeling mandates will standardize terminology across all manufacturers, which could be perceived as overstepping government authority and counter to their marketing strategies. OEMs may also resist uniform labeling fearing other motorists may challenge the capabilities of vehicles that are badged as automated.

6.11 Adherence to Traffic Laws

Background

Traffic laws are the purview of state and provincial jurisdictions, although local jurisdictions may enact additional traffic and parking laws. Although most traffic laws are similar from jurisdiction to jurisdiction, some are jurisdictional specific. For example, although all jurisdictions have laws regarding speed limits, minimum and maximum speed limits may vary significantly among jurisdictions (e.g., roads in some jurisdictions have no specified minimum speed limit). Similarly, traffic laws relative to vehicle movements commonly referred to as "rules of the road," such as lane changes, left- and right-hand turns, yielding right of way, stopping, passing, and movements in regard to traffic control devices and pedestrian crossings, and so on also vary among jurisdictions.

Where speed limits are concerned, it is common knowledge that compliance with these limits is often low, and drivers often adjust their vehicle speed to that of the prevailing flow of traffic. Users frequently set the vehicle cruise control to speeds that exceed the speed limit. In light of this common practice,

there is concern that future consumers of HAVs may desire similar discretionary control of the maximum operating speed leading manufacturers to develop HAVs capable of violating speed limits and other traffic laws. This would be legally imprudent and could be unsafe. However, manufacturers should give consideration to exigent circumstances when it may be necessary to perform maneuvers that may otherwise violate traffic laws, such as following the directions of police officers or flaggers to cross double yellow lines or drive on a sidewalk to avoid hazards such as at a crash scene, a flooded road, or road debris.

Please note impaired driving and distracted driving are addressed in other areas of this report.

Guidelines for Testing and Deployed Vehicles

Jurisdictions should ensure that all vehicles under their authority are required to adhere to all traffic laws and rules of the road, except in exigent circumstances. Jurisdictions will need to examine their traffic laws to identify laws that may not be relevant or appropriate for HAVs and amend them as necessary. For example, the New York traffic law requiring in part that a user maintain at least one hand in control of the steering mechanism at all times may not be appropriate where HAVs are concerned. However, because of the uncertainty of their deployment, it is likely premature to modify current traffic laws and regulations to accommodate SAE Level 5 vehicles at this time.

The Transportation Research Board (TRB) has undertaken a project to assist jurisdictions with updating their motor vehicle codes as HAV technology continues to evolve. See TRB project (NCHRP20-102(07) Implications of Automation for Motor Vehicle Codes.

Additionally, vehicles designed to operate in either automated mode or manual mode should not have the ability to override the HAVs settings allowing for violation of traffic laws without transitioning out of automated mode into manual mode.

Recommendations for Jurisdictions

6.11.1. Monitor the progress of the TRB project (NCHRP20-102(07) Implications of Automation for Motor Vehicle Codes to identify traffic and other laws that may need to be repealed or revised to accommodate HAV technology.

6.11.2. Jurisdictions should not modify current traffic laws specifically to accommodate SAE Level 5 vehicles until their development advances to the extent that such amendments and statutes are warranted.

Recommendations to Manufacturers and Other Entities

MOE 23. Manufacturers or other entities should ensure users of vehicles designed to operate in either automated mode or manual mode do not have the ability to override the HAV settings without transitioning out of automated mode into manual mode unless faced with an exigent circumstance.

Benefits of Implementation

Ensuring that HAVs are programmed to comply with all jurisdictional and local traffic laws will contribute to the safe operation of HAVs by avoiding the human decision-making process that currently contributes to most crashes.

Challenges to Implementation

Some consumers may demand more control over the functions of their HAVs, and manufacturers desire to accommodate the consumers. Additionally, it will be a challenge to ensure the HAV is updated with new and amended traffic laws during each legislative session from jurisdiction to jurisdiction.

Chapter 7 Next Steps

The foundation of this report and the recommendations herein are based on a combination of research, experience, and knowledge accumulated over the past three years by the members of the AVWG. Because the technology is rapidly evolving, it is critical for the AVWG to continue to learn and share their expertise for the benefit of AAMVA's members and the community as a whole. Their continued efforts are supported by the AAMVA Board of Directors and federal, state, and local stakeholders.

To advance its knowledge of the progression of HAV technology, the AVWG will continue to work closely with government entities, industry, and research stakeholders. In addition, the AVWG will maintain close contact with state government officials and national associations supporting transportation agencies, such as the AASHTO, NCSL, and GHSA. The AVWG will continue to work closely with federal, state, and local transportation agencies to understand the impacts on government programs and responsibilities and to share their expertise.

The AVWG will follow up with manufacturers and NHTSA to discuss recommendations made within this report. AVWG members will attend conferences, seminars, and other forums focused on technology and public policy. The member(s) will participate individually or in groups, as attendees, presenters, and panelists. Sharing their expertise will be a priority for the AVWG.

It is also anticipated that the members of the AVWG will assist jurisdictions to understand HAV technology and its impact on government programs. The AVWG will provide assistance to jurisdictions with implementation of the guidelines identified in this report as well as the information provided in Section II of NHTSA's *Automated Driving Systems: A Vision for Safety 2.0*.

The AVWG will assist the AAMVA TMS to update model driver manuals, knowledge tests, and skills tests to address the use of vehicle technology during driver testing. The AVWG will also assist the AAMVA IDEC Board to update driver license examiner training materials to address vehicle technology as it emerges.

To keep this report relevant and to provide the best possible guidance to the AAMVA community, it is expected the AVWG will update this report periodically. Updates will continue to address MVA and law enforcement concerns related to HAV testing and deployment. The updates are expected to include commercial HAVs and HAV fleet ownership, as well as other topics that emerge such as safety inspections, training for MVA staff, and so on. AAMVA will continue to work closely with and coordinate HAV initiatives through partnerships with the federal, state, local agencies, and other various stakeholders.

The AVWG is committed to keeping pace with the evolution of vehicle technology, providing timely information and sharing its expertise.

Appendix A Summary of Recommended Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles

The following is a summary of guidelines to ensure a framework of consistent regulation and oversight of HAVs throughout the jurisdictions for the safe testing and deployment of HAVs in an effort to establish uniformity among jurisdictions. Jurisdictions are not required to follow these guidelines; they are provided as recommendations for those jurisdictions that choose to regulate HAVs.

These guidelines apply to SAE Level 3, 4 and 5 vehicles, described as Conditional Automation, High Automation and Full Automation, unless otherwise stated.

Chapter 3. Administrative Considerations

3.1 Administration: Recommendations to Jurisdictions

3.1.1. Identify a lead agency to manage the HAV committee and its efforts.

3.1.2. Establish an HAV committee.

3.1.3. Develop strategies for addressing testing and deployment of HAVs in the jurisdiction.

3.1.4. Examine jurisdictional laws and regulations to consider barriers to safe testing, deployment, and operation of HAVs.

3.1.5. Jurisdictions that regulate the testing of HAVs are encouraged to take necessary steps to establish statutory authority and to use NHTSA's *Automated Driving Systems: A Vision for Safety 2.0* and later updates to frame the regulations.

3.1.6. HAV committee members, regulators, and legislators are encouraged to perform knowledge-gathering and information-sharing functions.

Chapter 4. Vehicle Credentialing Considerations

4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways: Recommendations to Jurisdictions

4.1.1. Require all manufacturers and other entities testing Level 3, 4, or 5 HAVs to apply for and be issued vehicle specific permits before testing on public roadways.

4.1.2. Establish a test registration permit application process for HAVs that does not create unnecessary barriers for manufacturers or other entities and requires the completion or attachment of the information listed in Section 4.1.

4.1.3. Require test registration permit information be available for verification at the time of vehicle registration issuance (new and renewal) either by presentation from the holder or through electronic means in jurisdictions where manufacturer or other entity-owned vehicles are required to be individually registered.

4.1.4. Require test registration permits to be carried in the test vehicle while present on public roadways within their jurisdiction. Permit information should be made readily available to law enforcement via electronic means by the issuing jurisdiction.

4.2 Vehicle Registration: Recommendations to Jurisdictions

4.2.1. Establish uniform language that will benefit law enforcement, the MVA, and other stakeholders for testing HAVs. Such language should use common terminology such as "HAV" for "highly automated vehicle" and Levels 3, 4, and 5.

4.2.2. Place a notation on the registration credential or electronic record of vehicles that have the capability to operate at Level 3, 4, or 5.

4.2.3. Recognize the registration, title, and plate issued by another titling jurisdiction for purposes of testing.

4.2.4. Establish a field on the registration credential or record for deployed vehicles that indicates the motor vehicle has automated capabilities, including those vehicles that can operate without a human driver.

4.2.5. Establish uniform language to aid law enforcement, the MVA, and other stakeholders. Such language should use common terminology such as "HAV" for "highly automated vehicle" and Levels 3, 4, and 5.

4.2.6. Consider using a separate field for HAV notation on the registration or credential for deployed vehicles (review *AAMVA's Best Practice for Registration Credentialing* for suggestions on open fields). See Section 4.3 Titling and Branding for New and Aftermarket Highly Automated Vehicles for more information.

4.3 Titling and Branding for New and Aftermarket Highly Automated Vehicles: Recommendations to Jurisdictions

4.3.1. Record and maintain the test vehicle information in the vehicle record through the normal titling process, through a titling exception process unique to HAVs or recording vital information in the database without titling. If a jurisdiction titles an HAV, the brand should indicate "highly automated vehicle."

4.3.2. Titles for vehicles with added aftermarket components enabling HAV functionality should be branded. The brand should indicate "highly automated vehicle."

4.3.3. Make a notation on a vehicle's record using "HAV" when the altered vehicle is capable of functioning at a Level 3, 4, or 5 as automated technologies continue to develop.

4.3.4. Title all highly automated deployed vehicles, including those altered by aftermarket part manufacturers, pursuant to the jurisdiction's laws or policies; each the title should be branded HAV and further designated by Level 3, 4, or 5.

4.4 License Plates: Recommendations to Jurisdictions

4.4.1. Jurisdictions should not require a special license plate for HAVs.

However, if a jurisdiction chooses to require a special license plate for HAVs, these plates should adopt the administrative, design, and manufacturing specifications contained in the *AAMVA License Plate Standard*.

4.5 Highly Automated Vehicle Information on the Manufacturer's Certificate of Origin or Manufacturer's Statement of Origin: Recommendations to Jurisdictions

4.5.1. Jurisdictions should not initiate a process for titling test vehicles if the jurisdiction does not already require this protocol.

4.6 Financial Responsibility: Recommendations to Jurisdictions

4.6.1. Require all HAVs permitted for on-road testing to have minimum liability insurance in the form and manner required by the MVA authority.

4.6.2. Follow current requirements for minimum liability insurance for deployed vehicles.

4.7 Federal Motor Vehicle Safety Standards (FMVSS) and Canadian Motor Vehicle Safety Standards (CMVSS): Recommendations to Jurisdictions

4.7.1. Consider requiring manufacturers or other entities testing HAVs within the jurisdiction to certify the vehicles comply with all applicable FMVSS or CMVSS and no required safety devices have been made inoperable. In lieu of the certification, evidence the vehicle(s) have been exempted from the regulations may be required.

Chapter 5. Driver Licensing Considerations

5.1 Driver and Passenger Roles Defined: Recommendations to Jurisdictions

5.1.1. Use the SAE International definitions provided in Chapter 2.

5.2 Driver License Requirements for Testing by Manufacturers and Other Entities: Recommendations to Jurisdictions

5.2.1. Review and develop or adapt existing rules, if applicable, regarding vehicle operation to ensure HAV testing is permitted.

5.2.2. Require test HAVs be operated solely by employees, contractors, or other persons designated by the manufacturer of the HAV or any such entity involved in the testing of the HAV.

5.2.3. Require test drivers to receive training and instruction related to, but not limited to, the capabilities and limitations of the vehicle and be subject to a background check as described in Section 6.2 Criminal Activity.

5.2.4. Require training provided to the employees, contractors, or other persons designated by the manufacturer or entity be documented and submitted to the jurisdiction's HAV lead agency along with other required information.

5.2.5. Support the safe testing without a human driver inside of the vehicle by requiring a user designated by the manufacturer of the ADS technology or any such entity involved in the driverless testing of the HAV to be capable of assuming control of the

vehicle's operations or have the ability to achieve a minimal risk condition.

5.2.6. Take steps to ensure motor vehicle laws allow for the manufacturer to safely test Level 4 and 5 vehicles without a licensed driver, provided a user designated by the manufacturer of the ADS technology, or any such entity involved in the driverless testing of the HAV, to be capable of assuming control of the vehicle's operations or have the ability to achieve a minimal risk condition.

5.3 Driver Training for Consumers of Deployed Vehicles: Recommendations to Jurisdictions

5.3.1. Promote consumer training on the use of HAV functions.

5.3.2. Encourage communication between dealers and consumers including, but not limited to, acknowledgement of the sections in the vehicle "owner's manual" that relate to the HAV functions.

5.3.3. Encourage manufacturers, dealers, and insurance companies to provide incentives for consumers to receive proper training on the use of HAV functions.

5.4 HAV Driver Training for Motor Vehicle Agency Examiners, Driver Education Programs, and Private Instructors: Recommendations to Jurisdictions

5.4.1. Provide training to driver license examiners on vehicle technologies, including the operation of HAVs.

5.4.2. Require driver education curricula to contain information on HAVs and to provide hands-on training in the use of HAV technologies.

5.4.3. Establish standards for the conduct and training of driver educators and private instructors for the training of drivers on the use of HAVs.

5.5 Driver License Skills Testing with Automated Vehicle Technologies: Recommendations to Jurisdictions

5.5.1. Include information on vehicle technologies and ADS in the jurisdiction's driver's manual, when provided by the AAMVA TMS.

5.5.2. Include questions addressing ADS in the jurisdictional knowledge test, when provided by the AAMVA TMS.

5.5.3. Jurisdictions should not allow the applicant to use convenience technologies, such as, the parking assist feature, for off-road skills tests or parking maneuvers during the road test. The applicant should be required to demonstrate the ability to park the vehicle.

5.5.4. Allow the applicant to use safety critical technologies for skills tests or parking maneuvers during the road test. These technologies, such as backup or other cameras, should not be disengaged for off-road testing.

5.5.5. Jurisdictions should not require applicants to deactivate safety critical technologies during the testing process.

5.6 Endorsements and Restrictions for Deployed Vehicles: Recommendations to Jurisdictions

5.6.1. Jurisdictions should not establish endorsements or restrictions on the driver licenses at this time.

5.6.2. Take steps to ensure their motor vehicle laws allow for the operation of Level 4 and 5 vehicles without a driver if the vehicle cannot be operated in manual mode.

5.6.3. Jurisdictions should not limit the operation of Level 4 and 5 vehicles to individuals who are licensed as drivers.

5.6.4. Jurisdictions should not impose any other requirements, such as licensure, sobriety, clean driving history, and so on, for nondrivers to use Level 4 and 5 vehicles.

5.6.5. Take steps to ensure a licensed driver is prepared and capable of taking control of the vehicle if the vehicle has DDT manual fallback.

5.6.6. Review jurisdictional laws and regulations related to unsupervised children in motor vehicles and adopt appropriate laws and regulations to ensure safety.

Chapter 6. Law Enforcement Considerations

6.1 Crash and Incident Reporting: Recommendations to Jurisdictions

6.1.1. Require HAV manufacturers to submit to the jurisdiction crash-related information and a summary of the manufacturer's analysis of the incident to expand the amount of HAV data and research.

6.1.2. U.S. jurisdictions should adopt the MMUCC 5th edition (August 2017) recommendation as soon as practicable.

6.2 Criminal Activity: Recommendations to Jurisdictions

6.2.1. Jurisdictions that have HAV permitting requirements as described in Section 4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways should require the designated test users (employees, contractors, and other persons) to pass a background check, including, but not limited to, a driver history review and a criminal history check, before authorization to operate a test HAV.

6.2.2. Jurisdictions that have HAV permitting requirements as described in Section 4.1 Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways should establish provisions which disqualify an agent or contractor of a manufacturer or other entity who have criminal records or a driving history that includes DUI, reckless driving, or other significant conviction history from operating an HAV in a test environment.

6.3 Distracted Driving: Recommendations to Jurisdictions

6.3.1. Consider the level of automation to which their distracted driving laws will apply.

6.4 Enforcement of Permit Conditions: Recommendations to Jurisdictions

6.4.1. Develop an internal process that includes an application for manufacturers to test on public roadways within the jurisdiction and include provisions for suspension or revocation of any permit to test on public roads if permit holders violate permit conditions.

6.4.2. Consider the imposition of penalties if the testing entity continues to operate or test in violation of a suspension or revocation order.

6.4.3. Hold test users responsible for violations of existing traffic laws subject to existing legal processes.

6.4.4. Jurisdictions should not use regulations developed for testing for deployed vehicles because these vehicles will have been adequately tested, evaluated, and certified for safety and compliance with FMVSS or CMVSS.

6.5 Establishing Operational Responsibility and Law Enforcement Implications: Recommendations to Jurisdictions

6.5.1. Define what enforcement actions can be taken and who or what is responsible when there is no human on board an automated test vehicle.

6.5.2. Clearly establish legal responsibility for every vehicle operating on public roads.

6.5.3. For vehicles classified as Levels 4 or 5, which may be operated without a licensed driver and when the driverless vehicle performs the DDT independent of human input, the registered owner should be responsible for its safe operation.

6.7 Law Enforcement and First Responder Training: Recommendations to Jurisdictions

6.7.1. Work with manufacturer's consumer training programs to make the HAV training available to first responders at no cost to agencies.

6.10 Vehicle Identification: Recommendations to Jurisdictions

6.10.1. Enact requirements for permanent labeling on the rear and sides of an HAV to better identify vehicles and improve safety and regulatory control.

6.11 Adherence to Traffic Laws: Recommendations to Jurisdictions

6.11.1. Monitor the progress of the Transportation Research Board project (NCHRP20-102(07) Implications of Automation for Motor Vehicle Codes to identify traffic and other laws that may need to be repealed or revised to accommodate HAV technology.

6.11.2. Jurisdictions should not modify current traffic laws specifically to accommodate SAE Level 5 vehicles until their development advances to the extent that such amendments and statutes are warranted.

Appendix B Summary of Recommendations for Manufacturers and Other Entities for the Safe Testing and Deployment of Highly Automated Vehicles

The working group offers the following recommendations to manufacturers and other entities for the safe testing and deployment of HAVs. These guidelines come from the recommendations provided in the report. Manufacturers or other entities are not required to follow these recommendations; however, they are provided to ensure the safe testing and deployment of HAVs.

These guidelines apply to SAE Levels 3, 4, and 5, described as, conditional automation, high automation, and full automation, respectively unless otherwise stated.

3.1 Administration

MOE 1. Manufacturers and other entities should interact with and respond to jurisdictional HAV committee questions and requests.

4.3 Titling and Branding for New and Aftermarket Highly Automated Vehicles

MOE 2. The OEM or the installer of the aftermarket automated technology, either parts or software systems, should notify the MVA when a motor vehicle has been altered by adding the automated vehicle technology.

4.5 Highly Automated Vehicle Information on the Manufacturer's Certificate of Origin or Manufacturer's Statement of Origin

MOE 3. Vehicle manufacturers should list automated capabilities on the MCO, MSO, or NVIS. This functionality should be listed in a new field on the MCO, MSO, or NVIS to avoid confusion with existing information.

5.1 Driver and Passenger Roles Defined

MOE 4. Manufacturers and other entities should use the SAE International definitions1 provided in Chapter 2.

5.2 Driver License Requirements for Testing by Manufacturers and Other Entities

MOE 5. Manufacturers and other entities should complete a background check and provide or ensure appropriate training for HAV test drivers. See Section 6.2 Criminal Activity on background checks.

6.1 Crash and Incident Reporting

MOE 6. Manufacturers should design HAVs to record vehicle behavior sensor data and the driver–vehicle interface. Law enforcement should be provided with access to this information as well as a minimum of 30-seconds pre-crash and post-crash data for completing a proper investigation.

MOE 7. Manufacturers should make EDR information retrievable in a standard, nonproprietary format for ready access by those duly authorized.

MOE 8. Manufacturers should include time stamping and GPS location in EDR data.

6.2 Criminal Activity

MOE 9. The manufacturer or other entity, operating in jurisdictions not requiring HAV permits, should require the designated test users (employees, contractors, and other persons) to pass a background check, including, but not limited to, a driver history review and a criminal history check, before authorization to operate a test HAV.

MOE 10. The manufacturer or other entity, operating in jurisdictions not requiring HAV permits, should disqualify an agent or contractor of a manufacturer or other entity who have criminal records or poor driving history from operating an HAV in a test environment.

MOE 11. Manufacturers should ensure HAVs leave an electronic fingerprint that can allow tracing of input data to whoever initiated them.

6.3 Distracted Driving

MOE 12. Manufacturers or other entities should prohibit users from all distracting activities when testing any HAV.

MOE 13. Manufacturers or other entities should design HAVs with a means of identifying when a vehicle is in automated mode to facilitate effective enforcement of distracted driving laws (i.e., so an officer knows if using a hand-held device is legal at the time of observation).

6.6 First Responder Safety

MOE 14. Manufacturers should ensure HAVs are permanently labeled, at a minimum, on the rear and sides of the vehicle for the safety of first responders.

MOE 15. Manufacturers should ensure HAVs have safety systems or procedures that allow first responders to immobilize or otherwise disable the vehicle post-crash to prevent movement or subsequent ignition of the vehicle for the safety of vehicle occupants and first responders.

MOE 16. Manufacturers should make the information regarding HAVs and procedures available to the first responder community in the jurisdiction where the vehicle will be operated.

6.6 Law Enforcement and First Responder Training

MOE 17. Manufacturers, in partnership with highway safety stakeholders, should develop national or international standardized first responder training on safely interacting with vehicles and users in both the testing and deployment of HAVs.

6.8 Vehicle Response to Emergency Vehicles, Manual Traffic Controls, and Atypical Road Conditions

MOE 18. Manufacturers should ensure that vehicles operated on public roads, both during testing and deployment, be able to recognize and properly respond to all temporary traffic controls and atypical hazards in the roadway environment.

6.9 System Misuse and Abuse

MOE 19. Manufacturers or other entities, such as researchers and developers, should record the behavior of the vehicle and the driver–vehicle interface at all times during operation because extensive testing occurs on public roads.

MOE 20. Manufacturers should design HAVs to record both vehicle behavior and the driver–vehicle interface to identify the actions of the vehicle and the actions (or lack thereof) by the driver at all times.

MOE 21. Manufacturers should ensure the EDR and CPU information that accomplishes *Recommendation MOE 20.* is stored and retrievable in some recognized, standard, nonproprietary, format for ready access by those duly authorized.

6.10 Vehicle Identification

MOE 22. Manufactures should develop international consensus standards for a system of permanent labeling of HAVs to ensure consistency of safety information on vehicles with automated features.

6.11 Adherence to Traffic Laws

MOE 23. Manufacturers or other entities should ensure users of vehicles designed to operate in either automated mode or manual mode do not have the ability to override the HAV settings without transitioning out of automated mode into manual mode unless faced with an exigent circumstance.

Appendix C Autonomous Vehicle Working Group Roster

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