# ADS and Traffic Regulations Voluntary Specifications Development Playbook

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**16. Abstract**

The purpose of this playbook is to identify the processes and activities necessary to create a stakeholder-administered, voluntary specification development and maintenance process for traffic regulation data to support automated driving systems. The playbook envisions a process whereby stakeholders convene as a working group to collaborate on specifications for capturing, managing, and disseminating traffic regulations data with an eventual transition of a mature specification to a standards development organization for formalization. Activities include stakeholder engagement, specification development, and administration of the specification. Appendices describe similar specification development efforts and alternatives.

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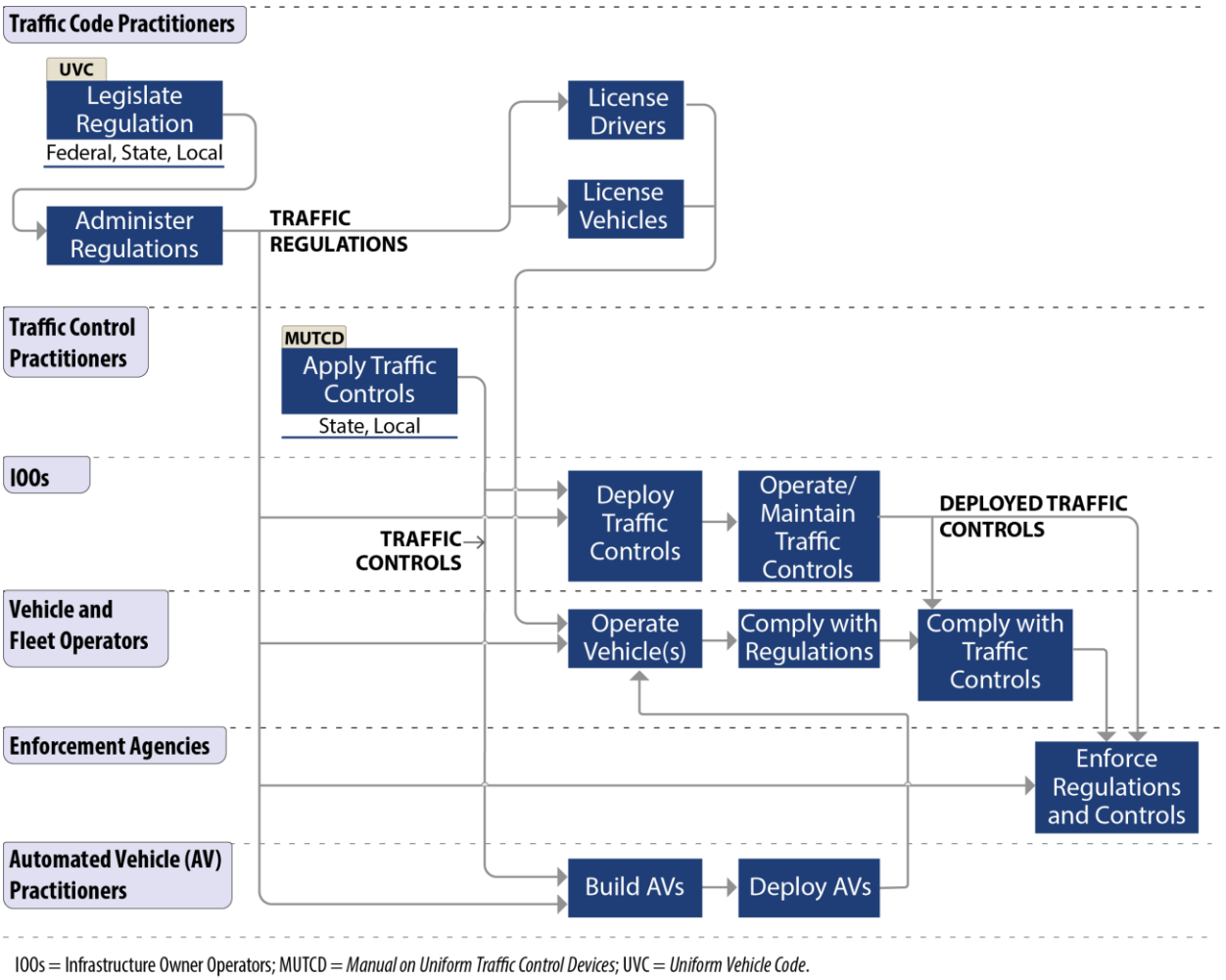
## List of Abbreviations

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ADS | automated driving system |
| ANSI | American National Standards Institute |
| CAV | connected automated vehicle |
| CWZ | connected work zone |
| FHWA | Federal Highway Administration |
| IOO | infrastructure owner-operator |
| ISO | International Organization for Standardization |
| ITE | Institute of Traffic Engineers |
| ITS | intelligent transportation system |
| ITS JPO | Intelligent Transportation Systems Joint Program Office |
| METR | Management of Electronic Traffic Regulation |
| MUTCD | *Manual on Uniform Traffic Control Devices for Streets and Highways* |
| OEM | original equipment manufacturer |
| SDO | standards development organization |
| TMDD | Traffic Management Data Dictionary |
| USDOT | U.S. Department of Transportation |
| WZDI | Work Zone Data Initiative |
| WZDWG | Work Zone Data Working Group |
| WZDx | Work Zone Data Exchange |

# About This Playbook

## Vision and Purpose

Automated driving system (ADS) developers have identified a need for data and database specifications that support digitizing rules of the road (i.e., traffic regulations) that ADS can use to operate in compliance with traffic regulations. The Federal Highway Administration (FHWA) initiated research and development of a prototype data framework for traffic regulations in 2019. The research identified a diverse set of stakeholders that support the administration of traffic regulations, deploy traffic control devices, and enforce traffic regulations. Perspectives provided by the stakeholders helped set expectations for development of the prototype and to start conversations about the development of voluntary specifications. This investigation also described data and interactions between traffic regulations and automated vehicles. Figure 1 shows these interactions, along with the key stakeholders.




IOOs = Infrastructure Owner Operators; MUTCD = *Manual on Uniform Traffic Control Devices*; UVC = *Uniform Vehicle Code*.

*Source: FHWA.*

**Figure 1. Diagram. Stakeholders, data, and interactions involved in traffic regulations and automated vehicles.**

Stakeholders interact with traffic regulations in roles ranging from legislators and their assistants who draft and enact traffic laws to those who enforce and adjudicate the laws as they are applied to traffic events and circumstances on the roadways:

- Traffic code practitioners include legislators and support staff, with input from commercial interests and the public. Licensing and administration authorities need to provide expectations for human drivers and ADS operations within their jurisdictions.
- Traffic control developers are those who develop uniform traffic control device descriptions. These developers typically are civil engineers, planners, and human factors specialists with knowledge of traffic management strategies and techniques and driver and vehicle behaviors. Members of

the National Committee on Uniform Traffic Control Devices have extensively participated in the FHWA research and development.

- Infrastructure owner-operators (IOO) are responsible for deploying, operating, and maintaining traffic controls on the roadways to support human drivers and ADS. Representatives of IOOs have informed the scope and provided stakeholder needs for this research.
- Vehicle and fleet operators plan trips, routes, and vehicle movements as they operate vehicles on the roadways.
- Enforcement agencies enforce compliance with the applicable regulations and traffic controls. In this context, the group can be extended to include adjudication of the traffic regulations in particular instances as played out in the courts and legal system. These stakeholders need to understand the implications of automated vehicles within the traffic flow and be prepared to interact with them appropriately.
- Automated vehicle and ADS developers broadly speaking are those who develop the hardware and software systems that will enable vehicles to operate without human drivers in an increasing range of ODDs. ADS developers provided many insights into user needs for a traffic regulation data framework as part of this research.

The blue boxes in figure 1 represent activities undertaken by the traffic regulation stakeholders to assure that vehicles and their drivers operate safely and effectively on the nation's roadways.

Traffic regulations are created and enacted at the Federal, State, and local government levels by legislators and their staff with input from transportation agencies, and to some extent, private commercial entities and the public.

Once enacted, the regulations are administered by other State and local agencies, such as departments of transportation, departments of motor vehicles, driver license bureaus, and State highway patrol and police. These administrative groups will also license drivers and vehicles for those jurisdictions in which they will be operating.

Development of traffic controls renders the intent of the legislated traffic regulations into forms that can be localized to the roadway for driver instructions and constraints on vehicle behavior. Each body of traffic regulations requires a set of traffic controls to be developed and applied within its jurisdiction.

Once the traffic control devices are defined, they need to be deployed to the roadways as applicable to the particular context for which the control is designed.

Dynamic traffic controls such as traffic signal systems need to be configured and operated so as to manage local traffic flow and safety conditions. Both static and dynamic controls need to be maintained such that they are visible and actionable by drivers and vehicles.

Licensed drivers are legally enabled to operate licensed vehicles on the roadways. These operations are to be in compliance with both traffic regulations—the body of traffic law applicable within the jurisdiction(s) in which the vehicle is operated—and the local traffic controls. This is an important distinction, in that the regulations are in practice implicit to those operations and may not be locally marked or signed. Regulations of this type might include rules such as speed limits on particular roadway classifications where not otherwise posted, right turns being permissible on a steady red signal, or "move over laws" when law enforcement and emergency workers are present. Vehicle operations are generally also subject

to local custom where actions are based on standards of reasonableness or implicit negotiation between vehicle operators.

Law enforcement operates both explicitly on the roadways and in the legal systems. Enforcement may be by State and local police and patrols, or by automated means in some jurisdictions. The application of traffic laws may need adjudication in the legal system when the laws depend on standards of reasonableness or operator judgement.

The forms of traffic regulations as they exist in the current world of human-driven vehicles, and as they will need to persist into a world of ADS and automated vehicles, are represented in the figure 1 diagram by ellipses.

The *Uniform Vehicle Code*[1] provides a set of traffic regulation on which State and local traffic codes may be based. It represents a historical consensus on traffic regulation, but has no legal standing and is not normative for regulations.

Traffic regulations are the rules of the road as detailed in the State and local statutes that describe the legal objectives and obligations, the operational requirements, and the consequences of violations.

The *Manual on Uniform Traffic Control Devices for Streets and Highways*[2] (MUTCD) is a common national standard for markings and signage on roadways. It both comes from and is used as a reference for development and application of controls by State and local agencies. The MUTCD is published by the Federal Highway Administration (FHWA).

Traffic controls represent the types of regulatory markings and signs on the roadways that may be needed to assure safety and preserve mobility in traffic movement. In this context, they represent the types of traffic controls based on the MUTCD with State and local variations.

Deployed traffic controls are markings and signs of various types as they are deployed on the roadways in particular locations for particular modes of operation at particular times.

Traffic regulation data exchange voluntary specifications are a key component of the traffic regulation data framework. The specifications ensure that infrastructure owner-operators (IOOs), ADS developers, and other data and technology suppliers (e.g., of maps and traveler information) build on the same foundations. Such specifications are not successful unless they are jointly designed by a variety of stakeholder groups reflecting diverse user needs and existing practices within their communities.

The purpose of this playbook is to identify the activities necessary to create a stakeholder-administered voluntary specification development and maintenance process for ADS traffic regulation data.

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[1] National Committee on Uniform Traffic Laws and Ordinances, *Uniform Vehicle Code* (Evanston, Illinois: NCUTLO, 1992).

[2] FHWA, *Manual on Uniform Traffic Control Devices for Streets and Highways*, 11th ed. (Washington, DC: USDOT, December 2023), https://mutcd.fhwa.dot.gov/pdfs/11th_Edition/mutcd11thedition.pdf.

# Context

FHWA research on providing traffic regulations for ADS development and applications has produced several documents that provide background and context for this playbook:

- *Detailed Analysis of ADS-Deployment Readiness of the Existing Traffic Laws and Regulations*[3] provides an overview of traffic regulations and ADS. The document describes the challenges of establishing a database of traffic regulations for ADS and proposes means to support sharing and consumption of the information within the ADS ecosystem. It describes the potential for collaboration among State and local traffic code stakeholders and ADS subject matter experts. The document looks at currently available data that support automated vehicle integration and investigates the issue of inconsistencies in U.S. traffic laws and how they affect ADS behavior.
- *Automated Driving Systems (ADS) Operational Behavior and Traffic Regulations Information – Concept of Use*[4] describes a conceptual traffic regulations data framework. It builds on the prior analysis to identify stakeholder needs, design concepts, use cases, and other considerations for the framework's design and development.
- *Automated Driving Systems (ADS) Operational Behavior and Traffic Regulations Information – Proof-of-Concept Demonstration Report*[5] details the design implementation of the framework concepts and its application in two use cases for intersection right-turn-on-red and freeway left-lane use.

A diverse group of stakeholders provided reviews and insights on this body of research in focused workshops. Discussions in the workshops expanded on the research by describing additional stakeholder needs and experiences in cataloguing and interpreting traffic regulations for ADS. Workshop insights helped identify additional use cases for simulation testing and in developing a scope, process model, and topics for this playbook.

Development of the playbook started with analyses of similar FHWA stakeholder-driven standards development processes. FHWA and the U.S. Department of Transportation (USDOT) Intelligent Transportation Systems Joint Program Office (ITS JPO) initiated the Work Zone Data Exchange (WZDx) interface specification process in 2018, working with a diverse stakeholder group through 2022 to produce an interface specification that has subsequently been taken up for consideration as a joint Institute of Transportation Engineers (ITE) and SAE International standard under the Connected

[3] Jiaqi Ma, Kyle Garrett, and Abby Morgan, *Detailed Analysis of ADS-Deployment Readiness of the Existing Traffic Laws and Regulations*, Report No. FHWA-HOP-20-013 (Washington, DC: FHWA, 2020).

[4] Kyle Garrett, Jiaqi Ma, and Abby Morgan, Automated Driving Systems (ADS) Operational Behavior and Traffic Regulations Information – Concept of Use, Report No. FHWA-HOP-20-041 (Washington, DC: FHWA, 2020).

[5] Kyle Garrett, Jiaqi Ma, Bryan Krueger, Aaron Cherney, and Ron Schaefer, Automated Driving Systems (ADS) Operational Behavior and Traffic Regulations Information – Proof-of-Concept Demonstration Report, Report No. FHWA-HOP-21-040 (Washington, DC: FHWA, 2023).

Transportation Interoperability banner. Other data exchange specifications related to ADS development have taken diverse paths to standardization, as described in appendix B.

The research then investigated alternative process models for development, establishment, and maintenance of a stakeholder-administered voluntary specification for ADS traffic regulation data. Appendix C identifies criteria for a successful process; describes alternatives for the process; and provides an analysis of the needs, risks, opportunities, and likelihood of success associated with each alternative. The approaches in appendix C are characterized as an end-to-end stakeholder process, an agency and industry partnership, and a formal standards development organization (SDO) process. The approaches share similar process steps, but with varying degrees of stakeholder diversity, commitment, and authority. The agency and industry partnership is used in this playbook as representing a balance of interests and engagement among stakeholder groups.

## Specification Process Overview

This playbook describes a hypothetical process for developing, establishing, and maintaining a traffic regulations data and interface specification for ADS. The process begins with the engagement of stakeholders with an interest in the outcomes of the specification process. Stakeholders in traffic regulations specifications for ADS have been previously identified, as shown in Figure 1, but are not yet working as a group on a common specification. Entities or groups with a vision for the specification objectives, potentially a group of stakeholders, SDOs, or trade associations, acts as conveners and invite stakeholders to participate in a working group. The complexity of the topic suggests that stakeholders are approached through agencies, SDOs, and associations that can socialize the concept and solicit interest in participation. Stakeholders include entities or parties that might eventually use the specification—as a data provider or consumer—or those that might technically support the development of the specification. The conveners may need to make the case for participation to each particular group of stakeholders, particularly for those who are not direct consumers of the data. Stakeholders want to know why their participation is important. The conveners initiate gathering the stakeholders and facilitates the setup of the working group.

Once the working group membership has been convened, its activities start with three items key to the success of the specification process: organizing for specification activities, identifying the scope of the specification, and establishing a plan for the group's subsequent activities. Organizing the working group establishes its leadership and preliminarily any subgroups that may need to be formed to facilitate development. Agreeing on the scope of the specification sets expectations and constraints on the process and the product specification, including criteria for completion of the working group activities. The plan describes the initial membership and organization of the working group and the process for development, support, and revision of the product specification. Documentation of these activities may take the form of a charter for the working group.

The process centers on the core specification development activities. These activities begin with capturing stakeholder perspectives, needs, and requirements to be reflected in the product specification. Phase 1 of the FHWA traffic regulations for ADS initiative captured an initial perspective and needs from stakeholders that have been validated by this playbook. The working group may consider this starting point and repackage and expand on those needs and perspectives.

Subsequent working group activities develop the specifications, review the specifications as individual members and as a collective working group, and refine the specifications accordingly. SDOs participate as working group members throughout this process to monitor its progress and provide insight toward eventual formalization of the specification as a standard. The precise structure and sequence of these activities depend on how the working group is organized. The refinement and review process continues iteratively until the specification fulfills the plan, intended scope, and completion criteria. The working group then manages the completed specification as it is maintained, and made available to stakeholders.

The playbook process envisions that one or more SDOs take up the completed specification for formalization as a standard according to the SDO's practices and procedures. The importance, complexity, and diverse stakeholder community in traffic regulations for ADS suggest that more than one SDO may need to be involved to ensure broad stakeholder representation. Any of the stakeholder groups shown in Figure 1 can use a standard for traffic regulations data for ADS**Error! Reference source not found.**. The working group continues to collect stakeholder experiences and comments on their specification applications and provide that information to the SDOs during the transition period. Table 1 gives an overview of the process described in the playbook.

**Table 1. Playbook overview.**

| Process Phase | Partnership Agreement | Working Group Charter | Collaborative Development | Stakeholder Review and Feedback | SDO Transition |
|---|---|---|---|---|---|
| Stakeholder Engagement | • Collaborative agreement<br>• Scope and goals<br>• Roles | • Form working group<br>• Set charter<br>• Organize working group | • Convene subgroups<br>• Review progress within working group | • Hold forums<br>• Solicit reviews<br>• working group<br>• acceptance | • Stakeholder use and applications<br>• Agency and industry endorsement<br>• Transition to SDO |
| Specification | | | • Define framework<br>• Set milestone objectives<br>• Engage experts<br>• Develop spec content | • Response to reviews<br>• Refine and finalize content | |
| Support | | | • Set up repository<br>• Develop fact sheets<br>• Capture spec content<br>• Distribute work in progress | | • Transition to SDO<br>• Further formalization by SDO<br>• Iterative revisions |

# Stakeholders and Leadership

**Decision Points** ?

- Who initiates the process?
- Who convenes the stakeholders?
- How are classes of stakeholders invited to the process?

The breadth of concern with traffic regulations and their interpretation for ADS implies a diverse stakeholder group. As Figure 1 shows, the stakeholders directly involved in identifying and applying traffic regulations to ADS include, at minimum:

- Regulations practitioners, such as legislative analysts, legislators, and vehicle and driver licensing agencies
- Traffic control practitioners at State and local agencies
- Infrastructure owner-operators who deploy, operate, and maintain traffic control devices with which ADS must comply in operations
- Vehicle and fleet operators of human- and ADS-controlled vehicles who must comply with traffic regulations and deployed traffic control devices
- Enforcement agencies who monitor and enforce compliance with traffic regulations and traffic control devices
- Automated vehicle practitioners who develop ADS for integration and deployment in automated vehicles

Stakeholders with related concerns include other road users (e.g., pedestrians and bicyclists), road workers, emergency service personnel, and adjacent businesses and residents.

Stakeholder groups might be represented by the following agencies and associations with collective interests in traffic regulations and ADS:

- USDOT and its constituent agencies
- American Association of Motor Vehicle Administrators
- National Council of State Legislatures
- National Committee on Uniform Traffic Control Devices
- American Association of State Highway and Transportation Officials (AASHTO)
- National District Attorneys Association
- Alliance for Automotive Innovation
- SAE International (SAE)
- ITE
- ITS America

Identifying the potential stakeholders leads to some fundamental questions and decisions: Who initiates the process? Who convenes the representative stakeholders to begin the process of developing a specification for traffic regulations data for ADS? How are classes of stakeholders invited to the process?

Stakeholders might act as representatives of agencies, associations, and business entities, or as individuals from any of the stakeholder constituencies. Over the long term, stakeholders might provide mutual assistance with implementation through voluntary association based on their roles relative to traffic regulations and ADS, much as, for example, information sharing and analysis centers support cybersecurity interests among stakeholder industries and roles.

## Organization, Structure, and Administration

This playbook provides an initial plan for developing a traffic regulations data and interface specification for ADS. The playbook discusses the purpose, context, and stakeholders; describes specification-related activities and their objectives; and lays out a process leading to a voluntary specification. Parties initiating and working the process may need to amend their plan as new stakeholders, opportunities, and technical challenges are discovered, subject to administrative procedures agreed to by the convening parties.

# Activities and Objectives

Developing a specification for traffic regulations for ADS is a complex process. The diversity of stakeholders and the technical difficulties of making regulations developed for human drivers available for ADS imply a need for a flexible but structured plan. Acknowledging and identifying the types of activities that are consistent throughout the specification process helps provide clarity, as Table 1 shows. The table rows align with the objectives of the process and the table columns show the flow of tasks and work products.

## Stakeholder Engagement

Stakeholder engagement activities ensure that the development of the specification is based on and conforms to the needs of the stakeholder users. Stakeholder activities occur throughout the specification development process, from the establishment of the working group through reviews and acceptance and transition to an SDO for formalization and maintenance.

## Specification of Data and Interfaces

The core technical activities describe and develop the content of the traffic regulations data specification for ADS. The working group convenes technical subgroups (i.e., task forces) as needed to assess and develop content for the specification. The task forces submit that content to the working group for iterative reviews and eventual approval.

## Support

Support activities include maintaining specification development content and products, such as fact sheets, flyers, and other socialization materials. These activities ensure the integrity of the specification content as it is developed, reviewed, and revised. Support might be provided by working group members (an open-source model), participating agency or association staff, or an interested SDO. The specification and supporting materials the working group develop remain available to SDOs for formalization after the working group has completed its activities.

## Revision

Revision activities formalize and manage specification updates beyond the initial specification development. Revision activities in this development model are transferred from the working group to an SDO.

# Part 1: Stakeholder Engagement

## Collaboration Agreement

**Decision Point** ?

What type of collaboration agreement, if any, is needed to form a working group?

The convening party invites potential stakeholders to participate in the process of developing the data and interface voluntary specification for traffic regulations. The initial gathering of stakeholders agree on the terms under which they work as a group toward that specification. The agreement has at least three parts: a statement of participant intent to work together, a description of the scope and goals of the group's activities, and identification of roles withing the group. The collaboration agreement may or may not be formalized, depending on the degree to which the parties want to document their potential financial and legal relationships in working together. The agreement is the foundation for development of the more detailed working group charter.

### Statement of Intent

The statement of intent may initially be only an expression of the group's intent to discuss interest in the topic. Over the course of the group's first meetings, this develops into a clearer vision and mission for the group activities. The intent is formalized by the group in the working group charter.

### Scope and Goals

The collaboration agreement describes the technical scope and goals of the intended specification. The scope may include its breadth (e.g., what items are included), depth (e.g., what layers of information at what level of detail), and milestones or time constraints on the group's activities. Goals within this scope clarify the specification's scope and objectives.

The specification needs to address rules of the road that are needed for ADS to safely operate in compliance with traffic regulations. The scope and objectives describe what specifications are needed to translate the written traffic regulations and traffic control device deployments into a digital format that ADS can understand. The scope describes whether to include the text of traffic statutes, rules for interpreting the statutes, or standard interpretations of rules for maneuvers described in the statutes. The scope considers how to interact with the existing traffic control device specifications in the MUTCD[6] as they might be interpreted by ADS. Other goals for the group's activities address related industry efforts and

[6] FHWA, Manual on Uniform Traffic Control Devices for Streets and Highways (Washington, DC: USDOT, 2023).

specifications, such as the Management of Electronic Traffic Regulation (METR)[7] specification being developed as an International Organization for Standardization (ISO) standard. Appendix B discusses related specifications, including METR.

### Roles

The initial collaboration agreement identifies leadership roles for continuing the next steps of building a working group. The convening party has an implicit leadership perspective, but it may be inappropriate for the convening party to continue in that role. Establishing roles early in a group process helps set expectations for participation. Setting up a steering committee builds commitment to continuing the work without necessarily identifying specific contributions from participants. The minimum description of roles in the collaboration agreement identify which parties are convening the working group for the next step of the process.

For traffic regulations and ADS, identifying roles and participants in the first meetings refers back to decisions about which stakeholders have been invited and the basis for their representation. Working through and with agencies and associations ensures broad representation of interest and resources for doing the work. A group formed from companies and interested individuals builds on the intensity of their interest. Both approaches have corresponding challenges to the formality of their participation and potentially to reaching eventual agreement on the contents of the specification. Roles for the working group, at minimum, include a chair and a co-chair to facilitate meetings. Other roles include leading the subgroups, taking and distributing proceedings notes, and managing specification documentation.

## Working Group Charter

A charter is an agreement for setting up a group, establishing its operating processes, and organizing to fulfill the group's goals. The formality of the working group charter reflects the perspectives of the agencies, associations, companies, and individuals participating in its formation. For developing specifications for traffic regulations and ADS, this may become more challenging with a broader scope and more detailed specifications. For perspective on establishing a charter in the context of a technical specification, the working group for development of the WZDx specification used a charter to describe its purpose and activities.[8]

### Form Working Group

Forming a working group seems implicit in gathering stakeholders to discuss the topic of mutual interest. In practice the working group takes form when the participants start to discuss the scope and structure for

[7] "Management of Electronic Traffic Regulations (METR)," presented at the 15th session of the Working Party on Automated/Autonomous and Connected Vehicles, January 23–27, 2023, Geneva, Switzerland, https://unece.org/sites/default/files/2023-01/GRVA-15-16a1e.pdf.

[8] "Work Zone Working Group Charter," GitHub (February 12, 2022), https://github.com/usdot-jpo-ode/wzdx/wiki/Work-Zone-Data-Working-Group-Charter.

their future work, as is then expressed in a charter or similar document. The working group for traffic regulations and ADS is convened from the prior first sessions on collaborative agreement and may include invitees identified in that first step.

### Set Charter

The first task for the working group is to develop a charter. The broad outlines of the charter may be discussed by the convened working group and formalized as a document by a smaller task force. The topics to be included in the outline are determined by the working group, but the Work Zone Data Working Group (WZDWG) charter[9] may serve as an example for the purposes of a specification for traffic regulations and ADS.

### Organize Working Group

Depending on the detail written into the charter, the working group creates subgroups to address downstream activities rather than discuss and do its work in a full working group session. For traffic regulations and ADS, this playbook suggests that stakeholder interactions and decisions as to the scope, direction, and disposition of the specifications are kept with the full working group. Technical work on the specification and providing support for working group records and specification versions are allocated to subgroups or task forces that report back to the working group. Task forces include specifying data for traffic statutes, traffic control devices, and machine-interpretable translations of traffic rules. Other task forces manage a GitHub site for working group records, develop fact sheets, and manage developing specification content.

## Collaborative Specification Development

The core activities of the working group convene the subgroups needed for developing the specification and review the progress of development as a full working group on a regular basis.

### Convene Subgroups

Subgroups identified by the full traffic regulations and ADS working group are convened to operate as task forces or committees reporting back to the full working group. Each such subgroup manages its activities and work products to its assigned objectives. There may be interactions with other subgroups on technical topics or to support records and work products.

### Review Progress within Working Group

The working group meets regularly, at least quarterly, to review the progress of the subgroups. Associated activities may include adjusting the scope and milestones among the subgroups, interacting with other

[9] "Work Zone Data Working Group Charter," GitHub (February 12, 2022), https://github.com/usdot-jpo-ode/wzdx/wiki/Work-Zone-Data-Working-Group-Charter.

specification and standards activities, and representing the working group's activities with other stakeholder and industry groups.

# Stakeholder Review and Feedback

While much of the specification development process is done by the subgroups, the full working group oversees the development and extend the review and feedback on the specification to the broader stakeholder community. If participation is based on representing agencies and associations, that may include outreach to those groups on technical issues or at important milestones in the development process.

The working group monitors the development and review process against the objectives specified in its charter. Depending on the terms of the charter, the full working group may want to document its participants' acceptance of the specification when those objectives are fulfilled.

## Hold Forums

The working group implicitly, or according to its charter, socializes the working group efforts and work products among broader industry stakeholders. Forums are one means of providing updates and receiving comments on the working group's progress. These informational meeting are specifically held by the working group or in cooperation with agencies and associations interested in the topic, such as those identified earlier in this playbook.

## Solicit Reviews

Although the main responsibility for review of the developing specification falls on the working group, there may be needs and opportunities for review by other interested groups. These reviews are set up as workshops by either the working group or interested agencies and associations.

# Specification Acceptance and Transition to Standards Development Organization

Completing the working group's objectives for the specification development is a significant milestone. Depending on the terms in its charter, the working group may convene at that time for acceptance of the completed specification, which may subsequently be made available to the participating agencies and industry entities for their acceptance. The completed specification is then transitioned to an SDO for formalization and maintenance.

## Working Group Acceptance

Working group acceptance of the completed specification concludes the development activities and is contingent on fulfilling the scope and objectives of the charter. This action needs to confirm that all comments received on the specification revisions have been addressed by the subgroups and that the

documentation is available to all participants. The working group charter specifies the procedures and form of working group acceptance.

## Agency and Industry Acceptance

Agencies and associations that have participated in or worked with the working group may want to offer their own acceptance and endorsements of the completed specification. Such acceptances and endorsements supplement the working group's acceptance.

## Release to Standards Development Organization

Acceptance of the completed specification by the working group indicates that stakeholders might use the specification on their own recognition of its merits. The specification is then released for continued formalization and maintenance by an SDO according to its own policies, procedures, and authority.

# Part 2: Specification

Collaborative development and stakeholder review of the work-in-progress specification is an iterative process, on a cadence set by the full working group. The working group assigns the work of developing the specification content to subgroups or task forces. The technical subgroups regularly report to the full working group on progress and to get full review of the work products.

## Collaborative Development

The technical subgroups work to define the framework and content for the specification and set milestone objectives for components within the framework. The subgroups engage subject matter experts as needed to address issues. The subgroup and expert content are then melded into the specification.

### Define Framework

The working group sets the objectives for the specification. The technical subgroups use the objectives as the basis for describing the specification's framework and contents. The framework establishes the basis for the subgroup's objectives, engagement with subject matter experts, and development of specification content. For traffic regulations for ADS, the framework includes frames for jurisdictions, traffic codes and regulations, traffic control devices, situations or driving domains, and maneuvers.

### Set Milestone Objectives

The subgroup milestone objectives provide structure and scheduling objectives for the specification development. The structural elements depend on the scope of the system objectives assigned to the subgroup. The scheduling objectives need to align with the working group schedule and review opportunities,

### Engage Experts

Subgroups may need to consult with subject matter experts to design and develop specification content, due to the complexity of the traffic regulations and ADS ecosystem. The consultations may be informal and point to other research for detailed information. Areas and topics needing new research are referred to the full working group for disposition.

### Develop Specification Content

The purpose and function of the technical subgroups is to develop content for the specification. This is likely an iterative process within subgroup meetings and in consultation with subject matter experts and other subgroups. Internal subgroup reviews resolve most issues. Draft specification content may be made available to the full working group for broader review.

# Stakeholder Review and Feedback

Stakeholders within the working group review the specification progress and provide feedback to subgroups. The subgroups refine the specification to resolve those comments and, eventually, finalize the content for acceptance by the full working group. This process may iterate through multiple versions of the developing specification as issues arise and new content is developed.

# Part 3: Administrative Support

Administrative support subgroups manage the specification working documents and work products from the technical subgroups on behalf of the full working group. It produces fact sheets and other socialization collateral at the direction of the working group.

## Collaborative Development and Stakeholder Review and Feedback

The support subgroup is the most active during the collaborative development of the specification and its ancillary work products.

### Set up Repository

The working group and technical subgroups need a shared repository for their work products. A GitHub repository similar to the WZDx specification repository is suitable, as long as there are no requirements for the repository beyond shared access and version tracking.

### Develop Fact Sheets

The working group may need to develop and manage fact sheets and other socialization collateral as part of its stakeholder engagement. These materials are developed by any subgroup and managed in the repository alongside other specification development material.

### Capture Specification Content

The technical subgroups develop specification content and documentation throughout the working group's existence. The support subgroup provides indexing and version control for these materials. Other documents that may be captured include meeting records, reference materials, example interface scripts, and application notes.

### Distribute Work in Progress

The potential number and diversity of stakeholders active in the working group and its subgroups suggest that working documents are captured and distributed through the version-controlled repository. This further suggests that some materials may need to be open only to limited distribution as works in progress.

# Acceptance and Transition to Standards Development Organization

Once the working group accepts the specification as meeting its objectives, the specification and its supporting documentation are retained and managed within the repository. The complete records are transitioned to an SDO if and when the specification is taken up for further formalization and revisions.

# Part 4: Revision

This playbook envisions that an SDO manages any revision to the eventual traffic regulations and ADS data and interface specification. The specification is picked up by an SDO whose membership sees a compelling and appropriate interest in development of that specification for formalization and maintenance as a standard. The self-selected SDO receives the specification after its acceptance by the working group. The specification is then managed by the SDO according to its own processes for formalization as a standard and for any subsequent revisions.

Candidates for administering the specifications include:

- SAE International
- ITE
- AASHTO
- American National Standards Institute (ANSI)
- ISO

# Additional Considerations

Identifying the technical scope of the interface specification and its relationship to other standards is key to planning working group activities and levels of effort. For example:

- Broader working group goals and use case scenarios may increase the diversity of stakeholder participants and technical complexity in specification applications.
- A broad scope and goals may overlap with other standards development programs.
- There is an order of magnitude increase in complexity between interface specifications for cataloging existing traffic regulations and for translating traffic regulations to machine-interpretable forms.
- A more detailed technical scope increases the level of effort and technical expertise needed to develop a working interface specification.

The first phase of FHWA's analysis of traffic regulations in ADS applications was limited to U.S. State and local jurisdictions. However, it may be possible to extend the scope of developing the interface specification to international applications with reasonable additional time and resources. ISO is developing the METR specification as an international standard and it is reasonable to expect a similar scope for the traffic regulations interface specification. At the least, it is beneficial for the traffic regulations specification working group to monitor and coordinate with ISO on interfaces between the regulations specification and the exchange specification.

Estimating resources for organizational and administrative support for the ADS traffic regulations data specification development process hinges on the scope of the specification. The conveners are best positioned to facilitate setting up the collaborative agreement, scope and goals, and roles, and expend effort in identifying and establishing relationships with the working group participants. Once the working group is assembled, facilitating its activities requires consistent sustained effort throughout the working group lifetime. Parties to the collaborative agreement expend resources toward working group activities according to the scope, timeline, and roles identified in the collaborative agreement.

## Points of Contact for This Playbook

Information regarding the genesis and intent of this playbook can be provided by contacting:

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# Appendix A. Application of the Work Zone Data Exchange (WZDx) Specification Approach

This appendix assesses the potential application of the process used in the development of the WZDx interface specification to the ADS traffic regulations data framework.

## Summary of WZDx Interface Specification Efforts

The WZDx interface specification is the result of a multiyear effort initiated by USDOT to improve the availability of work zone data among surface transportation system stakeholders.

USDOT is sponsoring WZDx specification and further development efforts in a connected work zone (CWZ) standards effort led by ITE, partnered with AASHTO, the National Electric Manufacturers Association (NEMA), and SAE International.[10] The formal systems engineering process to create a CWZ standard and reference implementation began in August 2022 and concluded in August 2024.

### WZDx Goals and Objectives

The goals and objectives of the WZDx are described in the online documentation as follows:

> The Work Zone Data Exchange (WZDx) Specification aims to make harmonized work zone data provided by infrastructure owners and operators (IOOs) available for third party use, making travel on public roads safer and more efficient through ubiquitous access to data on work zone activity. The goal of WZDx is to enable widespread access to up-to-date information about dynamic conditions occurring on roads such as construction events. Currently, many IOOs maintain data on work zone activity. However, a lack of common data standards and convening mechanisms makes it difficult and costly for third parties such as original equipment manufacturers (OEMs) and navigation applications to access and use these data across various jurisdictions. WZDx defines a common language for describing work zone information. This simplifies the design process for producers and the processing logic for consumers and makes work zone data more accessible. Specifically, WZDx defines the structure and content of several GeoJSON documents that are each intended to be distributed as a data feed. The feeds describe

[10] "Connected Work Zone Implementation Guidance Standardization (CWZ Standard)," Resources, ITE, accessed October 7, 20204, https://www.ite.org/technical-resources/standards/cwz/.

a variety of high-level road work-related information such as the location and status of work zones, detours, and field devices.[11]

## WZDx Stakeholders

WZDx stakeholders are a diverse group drawn from the transportation system IOOs, their contractors, travel information service providers, and travelers across all modes. Interactions among these stakeholders were initiated by USDOT.[12]

FHWA and ITS JPO co-led the early stages of the WZDx project and remain actively involved along with the Bureau of Transportation Statistics, Federal Motor Carrier Safety Administration, and others in the USDOT. Development of WZDx versions 2.0 through 4.2 was overseen by the WZDWG, established under the Federal Geographic Data Committee Transportation Subcommittee to maintain and update the WZDx Specification.

Attendees at the first WZDWG kickoff meeting represented USDOT and its contractors, AASHTO, ITE, State and local transportation agencies, traffic and navigation software providers, work zone device providers, automakers, ride-hailing services, and other commercial interests.

## WZDx Use Cases

The process used to develop the WZDx interface specification was intentionally agile and collaborative. There is no explicit documentation of use case descriptions in the GitHub repository. Use cases are implied throughout the meeting notes, issues board, and discussion board. Documentation of use cases is a part of the follow-on formal CWZ standard development work with led by ITE.

## WZDx Interface Specification Development Process

A summary of the WZDx interface specification development process may be instructive in identifying tasks and work products for a similar traffic regulations framework for ADS. The WZDx GitHub site provides substantial documentation of the process, primarily through the release history and working group meeting notes.

GitHub documentation[13] for the WZDx Specification v1.1 released in September 2018 records that work zone data producers and users collaborated to create the first version of the specification.

> The Federal Highway Administration (FHWA) and Intelligent Transportation Systems Joint Program Office (ITS JPO) co-led the early stages of the WZDx project and remain actively

[11] "wzdx_README.md at main usdot-jpo-ode_wzdx GitHub.htm," GitHub, accessed August 14, 2023, https://github.com/usdot-jpo-ode/wzdx/blob/main/README.md.

[12] "Connected Work Zone Implementation Guidance Standardization (CWZ Standard)," Resources, ITE, accessed October 7, 20204, https://www.ite.org/technical-resources/standards/cwz/.

[13] "WZDx Specification v4.2 Latest," GitHub, accessed October 7, 20204, https://github.com/usdot-jpo-ode/wzdx/releases.

involved along with the Bureau of Transportation Statistics (BTS), Federal Motor Carrier Safety Administration (FMCSA), and others in the USDOT. Several data producers and data users voluntarily developed v1.1 of the specification in collaboration with USDOT and have started to set up data feeds based on it.[14]

The kickoff meeting of the WZDWG in July 2019 established a charter, leadership, meeting cadence, and a WZDx Specification Subgroup.[15] The Specification (Update) Subgroup within the WZDWG met monthly to develop the WZDx interface specification v2.0. The specification v2.0 was voted on at the December 2019 WZDWG meeting and released in February 2020. The second semiannual WZDWG meeting in February 2020 initiated the Technical Assistance Subgroup and the Worker Presence Subgroup. The WZDx interface specification v3.0 was released September 2020, with a minor specification v3.1 in April 2021. The WZDWG chartered its Specification Extension Subgroup and Smart Work Zone Device Data Subgroup in June 2021. The WZDWG continued to develop major and minor interface specification releases up to v4.2 in February 2022. WZDx v4.2 is the last version created under the WZDWG governance structure.[16]

USDOT is sponsoring WZDx specification and further development efforts in a CWZ standards effort led by ITE, partnered with AASHTO, NEMA, and SAE.[17] The formal systems engineering process to create a CWZ standard and reference implementation began in August 2022 and concluded in August 2024.

WZDx faced a chicken-and-egg issue regarding deployment: Most DOTs would not commit resources to develop a feed until it was clear that potential data consumers would use them, and most data consumers would not use the feeds unless there was a critical mass of data feeds. This is in contrast to efforts such as the General Transit Feed Specification, which was motivated by a strong business case for data producers and consumers alike, since transit feeds draw more riders if route information is published on publicly available routing platforms and those routing platforms draw additional traffic by including transit schedules in its wayfinding. To achieve a scale of WZDx feeds, USDOT awarded 13 demonstration grants to State DOTs and local governments to develop WZDx feeds. As those projects ended and additional feeds from other DOTs came online, data consumers signaled readiness to develop integrations for WZDx feeds. Use of WZDx feed data for driver warning is not yet occurring at scale, however, largely due to data quality issues.

[14] "Work Zone Data Exchange (WZDx) Specification," GitHub, accessed October 7, 20204, https://github.com/usdot-jpo-ode/wzdx/tree/v1.1.

[15] "Work Zone Data Working Group Collaboration," GitHub, accessed October 7, 2024, https://github.com/usdot-jpo-ode/wzdx/wiki/.

[16] "Work Zone Data Working Group Collaboration," https://github.com/usdot-jpo-ode/wzdx/wiki/.

[17] "Connected Work Zone Implementation Guidance Standardization (CWZ Standard)," Resources, ITE, accessed October 7, 20204, https://www.ite.org/technical-resources/standards/cwz/.

### WZDx Work Products

WZDx work products are the released versions of the WZDx Specification and its supporting documents available on its GitHub site.[18] The site also has flyers and other collateral describing the Work Zone Data Initiative (WZDI), the WZDx interface specification, and how agencies can become involved in development of the specification and deployment of specification-compliant interfaces.

## Implications for the Traffic Regulations Framework for Automated Driving Systems

Although the content and scope of the WZDx interface specification are different than those of the traffic regulations framework for ADS, the processes by which the WZDx was developed have lessons for framework development. The initial version of the WZDx specification was produced prior to convening the standards working group. That team included USDOT, its contractor, and a small group of agencies willing to develop and deploy a prototype. This is similar to the phase 1 effort to develop a prototype ADS framework. Phase 1 did not explicitly publish a specification for the traffic regulations data and interface, but it is inferred from the requirements and the prototype implementation.

The WZDx stakeholder group included a balance of data providers and users. There seemed (based on meeting notes) to be a mutual understanding of the potential benefits of making work zone data more widely available. The ADS traffic regulations framework has reached out to a similarly broad set of stakeholders but has received more interest from the users in the ADS development community. The strategic roadmap may consider an initial focus on finding a committed small group of provider agencies to balance the perspectives.

The initial WZDWG meeting developed a charter to frame their work. ADS traffic regulations stakeholder groups have thus far met informally to provide input to the discovery process and to review documents. Part of the WZDI success may have derived from direct involvement in the technical work as described in their charter. The ADS traffic regulations roadmap may consider a working group charter as a means of structuring further interface development work.

The WZDx process did not formalize or capture specific use cases, which may have extended the period of discovery. The first activity in the CWZ effort was to backfill some of the traditional systems engineering documentation (including use case descriptions) that had otherwise been missing in WZDWG efforts. Use cases had been previously included in the phase 1 ADS traffic regulations concept of operations and reviewed with stakeholders in phase 2. That process revealed new use cases not captured in the phase 1 effort. The ADS traffic regulations working group might consider a rework and update to the use case descriptions, and more broadly to the concept of use, as a first set of technical tasks toward a consensus standard. The WZDx specification was not submitted for development into a formalized standard by an SDO—in that case, ITE—until it had been socialized and committed to by a significant number of data providers. Development of an interface specification for traffic regulations for ADS may benefit from a similar path.

[18] “Work Zone Data Working Group Collaboration,” https://github.com/usdot-jpo-ode/wzdx/wiki/.

# Appendix B. Application of the Standards

This appendix identifies voluntary specification models beyond the WZDx model and describes how elements of them can be applied to an ADS traffic regulation specification development process. This includes identifying the SDOs that have been involved in other FHWA-related data exchange development processes, SDOs associated with other related specifications, and SDOs that serve the various stakeholders that need to participate in the development of an ADS traffic regulations data specification development.

## Related Standards and Standards Development Organizations

This section identifies several data exchange standards related to FHWA interactions with ADS development and deployment. Table 2 lists the related standards, their associated SDO, and status as of October 2023. A brief summary of each exchange standard then describes its purpose, SDO management, and relevance to the exchange of traffic regulations data for ADS development.

**Table 2. Summary of related standards and standards development organizations.**

| Standard | SDO | Status |
|---|---|---|
| CWZ | ITE, AASHTO, and NEMA | Developing first version |
| General Transit Feed Specification (GTFS) | Gtfs.org, MobilityData.org (Canadian nonprofit organization) | Last revised March 14, 2023[19] |
| Connected and Automated Vehicle (CAV) Standards (J-series) | SAE | Many published standards, ongoing revisions |
| METR | ISO | Under development |
| Traffic Management Data Dictionary Standard for Center-to-Center Communications (TMDD) | ITE | v3.1 |

[19] "GTFS Schedule," General Transit Feed Specification, accessed October 7, 2024, https://gtfs.org/schedule/process/.

## Connected Work Zones

USDOT is sponsoring the CWZ implementation standard as a follow up to the WZDI. As stated on the project website:

> The primary objective of this project is to publish a nonproprietary, industry-based consensus standard that defines the key data elements, capabilities, and interfaces for a CWZ Standard, utilizing the USDOT-chartered WZDx Specification version 4.1 as a starting point, if available, otherwise we shall follow version 4.0.[20]

The project is currently developing systems engineering documentation as a basis for a 2024 first version of a final CWZ standard.

ITE is the convening SDO, working with the American Association of State Highway and Transportation Official (AASHTO), and the National Electric Manufacturers Association (NEMA) on behalf of USDOT. The CWZ Working Group includes representatives of ITE, AASHTO, NEMA, and at-large members from select other interested commercial parties.[21]

The WZDx specification up to version 4.2 was developed by a working group convened and led by USDOT. The transition of that specification to SDOs led by ITE demonstrates a possible pathway for a traffic regulations framework for ADS from direct USDOT leadership to a broader standards support community. As with the WZDx transition to CWZ, USDOT might consider sponsoring the SDO ownership of the resulting standard effort.

## General Transit Feed Specification

The development of the WZDx was modeled on prior open-source standards development for the GTFS, which identifies its purpose as:

> The General Transit Feed Specification (GTFS) is an Open Standard used to distribute relevant information about transit systems to riders. It allows public transit agencies to publish their transit data in a format that can be consumed by a wide variety of software applications. Today, the GTFS data format is used by thousands of public transport providers.[22]

The technical description of the GTFS is available at https://gtfs.org/schedule/reference/.

Consistent with its origins, the GTFS is managed by the nonprofit MobilityData group.[23] As indicated on their website, MobilityData acts as the SDO for the GTFS and the General Bike Feed Specification.

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[20] "Connected Work Zone Implementation Guidance Standardization (CWZ Standard)," Resources, ITE, accessed October 7, 20204, https://www.ite.org/technical-resources/standards/cwz/.

[21] ITE, *Connected Work Zone Working Group*, February 3, 2023, https://www.ite.org/ITEORG/assets/File/Standards/CWZ%20WG%202_2_2023.pdf.

[22] "General Transit Feed Specification," MobilityData, accessed October 7, 2024, https://gtfs.org/.

[23] "MobilityData," accessed October 7, 2024, https://mobilitydata.org/.

Membership in MobilityData is open to any interested organizations. Current members include private sector companies, government agencies, and nonprofit organizations.

Management of the GTFS more closely resembles open-source software development and version control processes than it does more traditional standards management as practiced by SDOs supporting other transportation standards. This appears to have an advantage of open participation in the revision process. The GTFS is available at no charge online and does not require membership or a license fee to access, unlike standards from SDOs such as IEEE and SAE.

## Connected and Automated Vehicle Standards

The ongoing industrywide development of CAV technologies has engendered a similarly broad development of standards to support that development. Many of the CAV data standards have been developed through SAE International and its processes in families of related standards including the SAE® J2735™[24] and SAE® J2945™[25] series.

SAE has its beginnings as an engineering association in the automotive industry. It has built from those beginnings to become the default SDO for automotive engineering standards as well as for aerospace and mobility standards. Individuals and organizations are eligible for SAE membership. Participation in standards development is controlled by but not explicitly limited to SAE members.

Management of standards development in the SAE process is driven by small core teams of self-selected subject matter experts in the topic of each standard. Review processes are more publicly accessible. SAE retains a vehicle-centric view of data and systems.

## Management of Electronic Traffic Regulations

As identified as part of the basis for this research, automated vehicles—more specifically, ADS—need information about traffic regulations to operate safely throughout the transportation system. International efforts are underway to develop a series of standards for METR. The basis for the METR effort is described in an informational flyer:

> What if vehicle operational regulations were digitized by their creators (or a surrogate), and provided to the vehicle operators through a well-defined, publicly available interface? A robust, secure means of exchanging trusted, machine interpretable information concerning rules of the road, traffic regulations, and ordinances will remove this barrier. We call this the Management of Electronic Traffic Regulations (METR).[26]

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[24] *V2X Communications Message Set Dictionary*, SAE J2735™, SAE International, https://www.sae.org/standards/content/j2735_202309/.

[25] *Dedicated Short Range Communications (DSRC) Performance Requirements for V2V Safety Awareness*, SAE J2945™, SAE International, https://www.sae.org/standards/content/j2945/2_201810/.

[26] "Management of Electronic Traffic Regulations (METR)," presented at the 15th session of the Working Party on Automated/Autonomous and Connected Vehicles, January 23–27, 2023, Geneva, Switzerland, https://unece.org/sites/default/files/2023-01/GRVA-15-16a1e.pdf.

This scope of effort complements and does not duplicate research into the voluntary development of specifications and provision of traffic regulation information for ADS. METR is addressing the formatting, management, and distribution of the traffic regulations data translated from the source rules into METR-formatted rules.

METR is currently under development by ISO under its technical committee ISO/TC 204 for intelligent transport systems.[27] U.S. participation in the ISO standards efforts is coordinated by ANSI. There are eight work items in the METR series of standards:

- ISO/DTS 24315-1: METR Vocabulary
- ISO/CD TS 24315-2: METR Operational Concepts (ConOps)
- ISO/CD TS 24315-3: METR System of systems requirements and architecture (SoSR)
- ISO/PWI TS 24315-4: METR Regulation system requirements (RSR)
- ISO/PWI TS 24315-5: METR Distribution system requirements (DSR)
- ISO/PWI TS 24315-6: METR Consumer system requirements (CSR)
- ISO/PWI TS 24315-7: METR Discrepancy handling system requirements (DHSR)
- ISO/PWI TS 24315-8: METR Data requirements

METR development of management and distribution standards for traffic regulation complements voluntary development of specifications and provision of traffic regulations data. Further development of a traffic regulations data framework for ADS will monitor and work with METR data and interface specifications. Any established SDO in the United States that would take up the voluntary traffic regulations data specification would be connected to the ISO METR activities through ANSI.

## Traffic Management Data Dictionary

As described on the TMDD informational page:

> The Traffic Management Data Dictionary (TMDD) Standards were developed to support center-to-center communications as part of the regional deployment of ITS in order for centers to cooperate in the management of a corridor, arterials, incident mitigation, event management, etc. Hence the TMDD provides the dialogs, message sets, data frames, and data elements to manage the shared use of these devices and the regional sharing of data and incident management responsibility.[28]

The TMDD's beginnings in collecting and sharing information from ITS devices inherently suggest that there are relationships between traffic regulations data and the data associated with traffic control devices. The TMDD and its updates are managed by ITE on behalf of ITE and AASHTO. The TMDD and

[27] *Intelligent Transport Systems – Management of Electronic Traffic Regulations (METR) Part 1: Vocabulary*, ISO/AWI TS 24315-1, International Organization for Standardization, https://www.iso.org/standard/78408.html. https://www.iso.org/standard/78408.html.

[28] "Traffic Management Data Dictionary (TMDD) Standard for the Center-to-Center Communications," Resources, ITE (accessed May 2, 2024), https://www.ite.org/technical-resources/standards/tmdd/.

a data framework for traffic regulations data are similar in that they are both concerned with management of traffic control information and devices. Both data sets are of concern to IOOs that are the natural constituents of ITE and AASHTO. Traffic regulations data for ADS has additional stakeholders who may not be familiar with the TMDD and the ITE/AASHTO arrangements.

## Implications for the Traffic Regulations Framework for Automated Driving Systems

Stakeholders in traffic regulations data for ADS have a specific interest in a complex data set that is not a natural fit with SDOs providing related standards management. The authoritative legal status of the regulations data is different than the operational data types in the WZDx, GTFS, CAV standards, and TMDD specification. The METR specification provides management and distribution of regulatory data but does not address the data definitions for the regulatory data itself.

Stakeholders in traffic regulations data for ADS have varying positions on what level of detail needs to be accommodated in the specification. The concept of use from the prior phase of work presumed that the framework manages references to and selections from original traffic statutes and potentially from legal interpretations of those statutes. Interactions with stakeholders in this phase of the research suggest a growing interest among ADS developers in capturing and standardizing machine-readable interpretations of the regulations.

Given these considerations, the stakeholder group for a specification for traffic regulations for ADS is broader than is usual for related standards development for transportation data systems. Much as the WZDx and GTFS efforts initially drew from very diverse groups of interested stakeholders, the initial rounds of specification development for traffic regulations for ADS benefit from being as open as practicable.

A core group representing all roles, identified in Figure 1 and Table 2**Error! Reference source not found.** is convened to propose a scope of specification and subsequently convene stakeholders to initiate an open standards development process. The path to a successful voluntary specification then appears to hinge on having a consensus among that initial stakeholder group at whatever level of detail is achievable. Subsequent development of the specification might go to any of several SDOs, depending on the scope and content of the consensus standard.

# Appendix C. Development Alternative Scenarios

This appendix identifies alternative scenarios for development, establishment, and maintenance of a stakeholder-administered, voluntary specification for ADS traffic regulation data. Each alternative is described in terms of stakeholder roles in initiating the specification process, developing the initial specification, supporting its distribution and use, and maintaining the specification through future revision. These alternative scenarios are not intended to be an exhaustive list of options. Each alternative scenario is evaluated against the success criteria for the most viable pathway for developing and maintaining the specifications. Timelines for each alternative depend on the balance of institutional support and voluntary effort utilized for the alternative. Sponsored specification development effort is likely to move more quickly than purely voluntary efforts.

## End-to-End Stakeholder Process

Stakeholders drive the specification process from start to finish. A group of self-selected stakeholders, likely already working together on traffic regulations models for ADS development, initiates the process and invites stakeholders to join their deliberations. Invitations to this working group initially include ADS developers, IOOs representing areas in which automated vehicles might be deployed for testing, vehicle and driver licensing agencies, and law enforcement agencies. The intent is to establish a diverse and large enough working group to attract additional stakeholders as the specification process moves ahead. The working group then establishes its own charter and organization for developing the specification, probably with an orientation toward agile methods and tools. Technical subworking groups are likely be formed to develop content for the specifications, reporting back to the full working group for review. Interim releases of the developing specification are tested independently by stakeholders. Specification management uses an open-source process through GitHub or other similar repository. The eventual voluntary specification is maintained by a similar working group, perhaps through a stakeholder-supported nonprofit organization formed for that purpose.

This process in this scenario is similar to that used to start, develop, and maintain the GTFS. It has a strength of being entirely supported by its stakeholders according to their specific interests and objectives. All stakeholders in the GTFS generally benefitted from generating and using transit schedule data in a voluntary specification. This approach is challenged in addressing the potential concerns of stakeholder groups for whom there are potentially more costs than benefits in supporting the specification and its implementation. The costs and benefits of fulfilling a traffic regulations data specification may be unevenly spread across the stakeholders. ADS developers, for example, directly benefit from the standardization and aggregation of regulations data. Vehicle and driver administrators have an interest in ensuring that regulations are followed, but less stake in standardizing the regulations or data with other jurisdictions. Gaining buy-in and participation from potential stakeholder groups benefits from finding a common set of objectives for the effort, even if the benefits do not directly accrue to the working group members.

The use of agile methods in this scenario not only fosters transparency but also encourages innovation and community-driven development. The process includes regular stakeholder updates, open forums for discussion, and clear guidelines for contributions to ensure that the framework is structured and effective.

The end-to-end stakeholder process for developing ADS traffic regulation specifications presents a mix of advantages and challenges. On the positive side, its inclusive and collaborative nature ensures broad participation and input from a diverse range of stakeholders, fostering a strong sense of ownership and commitment to the developed specifications. Additionally, the adaptability and innovation inherent in this approach, particularly through the use of open-source methods, enable flexibility and responsiveness to technological advancements, thus encouraging creative and forward-thinking solutions. However, there are notable drawbacks. The absence of a centralized authority can lead to potential inefficiencies in the process, as it may encounter decision-making challenges and directional ambiguities, potentially causing delays or divergent outcomes. This is particularly so for ADS regulation specifications since not all stakeholders have consistent views on this newly emerging issue. Moreover, the perception of costs and benefits can vary significantly among different stakeholder groups. This uneven cost-benefit distribution can affect the level of engagement and support from various parties, as some may not see immediate or direct advantages from their participation in the specification development process.

The steps illustrated in Figure 2 are typically undertaken to effectively implement the end-to-end stakeholder process.

1. **Stakeholder Self-Selection and Initial Meeting:** Key stakeholders who have shown an interest in ADS traffic regulations come together to initiate the process. This meeting focuses on setting preliminary goals and establishing a collaborative atmosphere.
2. **Establishment of Open-Source Framework:** The stakeholders decide on using open-source platforms for specification development, setting up online collaboration tools and repositories.
3. **Specification Development:** Leveraging the open-source model, the group collaboratively drafts the specifications, inviting inputs from a broader community, including external experts and public contributors.
4. **Open Review and Iterative Refinement:** The draft specifications are published for open review, allowing for a wide range of feedback and iterative improvements.
5. **Community-Based Finalization and Release:** The final specifications are agreed upon by the stakeholder group and released to the public, with an emphasis on community acceptance and support.


*Source: FHWA.*

**Figure 2. Diagram. End-to-end stakeholder process.**

# Agency and Industry Partnership

The ADS traffic regulations specification process is undertaken by a partnership of public agencies and industry. In this scenario, the initial stakeholder group is convened by USDOT, regulators through a group such as the National Conference of State Legislators, AASHTO, and industry groups such as the Association for Automotive Innovation, the National District Attorneys Association, and the American Automobile Association. The representatives of those entities establish a charter, working group organization, and process for developing the specification. That working group continues to sponsor development, records, and user support for the specification process through to an agreed-upon state of maturity. The working group passes the completed specification to an SDO for formalization, maintenance, and future revisions.

This scenario reflects the success of the WZDX specification process and its evolution toward a formal standard. The process is familiar and immediately establishes accountability to the agencies and associations of stakeholders most affected by the specification objectives. This scenario may be challenging if institutional agreements and arrangements are needed to set up working group or sponsor its work.

The Agency-Industry Partnership approach has several advantages, such as the combination of expertise from both public and private sectors, which can lead to efficient and well-rounded specification development. It may also face bureaucratic challenges due to the involvement of multiple entities with differing agendas and procedures. Additionally, there is a risk of unequal stakeholder representation, where some groups might have more influence over the process than others, potentially leading to imbalances in the specifications developed.

The steps illustrated in Figure 3 are typically undertaken to effectively implement the agency-industry partnership process for specifications.

1. **Partnership Agreement:** Key agencies and industry entities reach agreements to collaborate, outlining roles, responsibilities, and shared objectives.
2. **Joint Working Group and Charter Development:** A joint working group is formed, comprising members from both public agencies and industry. They develop a detailed charter that guides the specification process.
3. **Collaborative Drafting:** The working group collaborates on drafting the specification, setting development milestones and quarterly check-ins to monitor progress.
4. **Stakeholder Review and Feedback:** The draft is circulated among participating agencies and industry stakeholders for comprehensive review and feedback.
5. **Acceptance and Transition to SDO:** Upon finalization, the specifications are accepted by all participating entities and are handed over to an SDO for formalization and dissemination. This step proceeds according to the SDO policies and procedures for formalization of a standard developed by a working group outside the SDO.


*Source: FHWA.*

**Figure 3. Diagram. Agency-industry partnership process.**

# Formal Standards Development Organization Process

The ADS traffic regulations specification process is directly pursued by an SDO that has a compelling and appropriate interest in developing that specification. The process then proceeds under the normal policies of that SDO in seeking stakeholder participation, development, and maintenance. This approach is characterized by its structured methodology, reliance on established norms, and a formalized pathway for specification development and approval.

This scenario is prominent, for example, in the development of other automated vehicle and ADS standards by organizations such as the Society of Automotive Engineers (SAE). These processes are familiar, established, and formalized, providing a level of predictability and rigor that is beneficial for complex technical specifications.

The challenge for an ADS traffic regulations specification under this model is to attract expertise from all stakeholder perspectives to work on the specification under a single SDO, which is normally representative of a subset of those stakeholders. To address this challenge, it is important to actively invite and facilitate the participation of a diverse range of stakeholders, including those who are not traditionally involved in technical SDO activities.

The formal SDO process for developing ADS traffic regulation specifications commences with initiation and planning by the SDO, recognizing the need for a new specification. This phase involves the formation of a steering committee, comprised of members from varied sectors such as government, industry, and academia. Subsequently, the SDO undertakes stakeholder identification and engagement, pinpointing key stakeholders from relevant government agencies, industry experts, academia, and communities potentially impacted by the specifications. This involves direct outreach, public announcements, and collaboration with other organizations to ensure broad participation. The draft development stage is facilitated by the SDO, where numerous working group meetings, data gathering, research, and iterative drafting take place, typically in subcommittees each focusing on different aspects of the specification. Once a draft specification is developed, it is opened for public review, allowing input from various sectors to ensure the specification is comprehensive and inclusive of diverse viewpoints. Following this, based on the feedback received, the specification undergoes revision and enters the SDO's formal approval process, often involving a voting process by a larger committee or the SDO's membership. Upon approval, the specification is formally published and disseminated through various channels to ensure broad adoption and awareness. The SDO remains responsible for the maintenance and updates of the specification, continuously incorporating feedback and adapting the specification to align with technological advancements and regulatory changes, thus ensuring its ongoing relevance and applicability.

A recent example of this process is the development of the SAE Cooperative Driving Automation Standards (SAE J3216 and SAE J3282). In this case, FHWA played a key role in initiating and supporting the development of these standards. FHWA provided funding and facilitated stakeholder engagement in order to consider a wide range of perspectives in the development process. This collaboration accelerated the standard's development, demonstrating the effectiveness of government and industry partnership in SDO-led processes.

The formal SDO process for ADS traffic regulations specification, while structured and methodical, presents both advantages and challenges. The pros of this approach include a formalized process that lends credibility and wide recognition to the specifications developed. This formalization ensures that the specifications adhere to established norms and rigorous standards, making them reliable and authoritative. However, there are cons to this approach as well. The process can be slow due to the inherent bureaucracy and procedural requirements of formal SDOs. Additionally, there is a risk of limited stakeholder diversity. The traditional SDO membership may not fully represent all interests, particularly those of smaller or nontraditional stakeholders. This lack of diversity can lead to specifications that do not fully address the needs and concerns of all impacted parties.

The steps illustrated in Figure 4 are typically undertaken to effectively implement the agency-industry partnership process for specifications.

1. **SDO Initiative and Stakeholder Consultation:** The SDO initiates the process, consulting with key stakeholders to identify needs and scope for the new specification.
2. **Expert Committee Formation and Initial Drafting:** An expert committee, including representatives from various sectors, is formed to start the drafting process, focusing on technical rigor and compliance with established standards.
3. **Focused Development and Internal Reviews:** The committee intensively develops the draft, conducting multiple rounds of internal reviews to ensure accuracy and completeness.
4. **Formal Stakeholder Engagement and External Review:** The draft is opened to a broader stakeholder base for formal review, incorporating external expertise and perspectives.
5. **SDO Final Approval and Official Publication:** Following stakeholder feedback, the specification undergoes final approval by the SDO and is officially published, marking its formal adoption.


*Source: FHWA.*

**Figure 4. Diagram. Formal SDO specification process.**

# Analysis of Opportunities, Risks, and Likelihood of Success

The scope of the ADS traffic regulations specification is uncertain. The first phase of this initiative developed a basis and prototype around capturing and structuring a catalog of traffic regulations and traffic control devices for specific jurisdictions. ADS developers have stated in this phase of the work that

they want to have an additional layer of standardization and interpretation resulting in regulations that can be algorithmically interpreted by the ADS. Each of the process alternatives for developing a specification includes definition of scope of the specification as an early activity.

The specification for ADS traffic regulations needs input from stakeholders with widely varying incentives for participation. It may be challenging to address potential imbalances among stakeholders in the costs and benefits of implementing the specification. These incentives (or lack thereof) may affect the availability and willingness of some stakeholders to participate in the process. Invitations to participate describe the common safety and economic benefits of the voluntary specification, perhaps addressing the particular needs of each target stakeholder group. Agency or industry group sponsorship also boosts participation.

For regulators, the regulations stand as they are without additional incentives to reformulate or distribute them. It is conceivable that ADS deployment using a voluntary specification might reduce the downstream risks of developers lobbying to amend the traffic regulations in particular jurisdictions. As such, regulators might collectively have an incentive to build their understanding of ADS needs before deployments have an opportunity to create new challenges.

IOOs are responsible for deployments of traffic control devices, but not for management or interpretation of the underlying regulations. Supporting the voluntary specification increases the likelihood of compliance with the devices and regulations and facilitate safer integration of ADS-equipped vehicles into traffic operations.

ADS developers want to reduce the cost, effort, and potential liability to interpretation of regulations. These objectives incentivize sharing of those costs in developing a voluntary specification. Vehicle and fleet operators want assurance of ADS compliance with all regulations, but do not have direct influence over regulations or interpretations of regulations. Their participation in the working group is based on a need to understand and influence ADS operations safety and potential future operations liabilities.

Local enforcement and emergency management agencies interpret and enforce regulations for all forms of vehicle operators. They have little or no control over the means by which an ADS might interpret and maneuver in response to the regulations. They may be moved to participate in the working group by the opportunity to influence ADS operational margins to regulatory limits or access to vehicle operations logs in incidents.

No single SDO is likely to have the breadth of membership needed to address all ADS traffic regulation stakeholder perspectives. The specification's attributes and interpretation of the regulations are relatively detailed, but the use cases and implications of the specification affect a broad stakeholder constituency.

The management of regulatory data carries an implicit responsibility for the accuracy and security of the data and its specifications. That responsibility may be passed on with respect to the interpretations of the regulation to users of the specification. This implies a prescriptive need to ensure that regulatory stakeholder interests are represented in developing the specification. A specification developed without that regulatory input defers confirmation of the specification content until after development. Each alternative scenario includes the potential to involve regulators and addresses the accuracy and security of the data as part of the specification.

ISO is in the process of developing a specification METR, which is intended to describe the framework for trusted exchange of regulations data but does not specify the content of the data to be exchanged. The ADS traffic regulations specification describes a message, whereas METR is specifying the envelope in which the message is sent. Some data, for example, about the authority behind the content, or assurance that the content is legitimate, or even the size of the allowed messages, may be needed in specifications for both the message and the envelope. The METR specification development may have an impact on those data elements needed for voluntary collection and processing of traffic regulations data. The fully developed ADS traffic regulations playbook and working group processes need to address the interactions with the METR development activities and the METR specification. Specifications on the message packaging (to fit the METR specification) and on common data specifications may need to be synchronized to the METR development process.

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