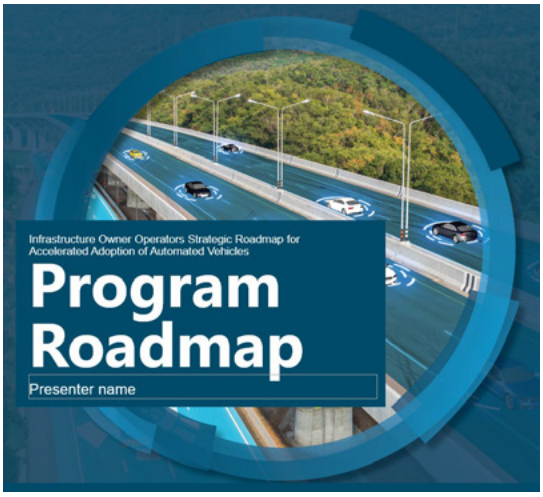
Infrastructure Owner Operator (IOO) Strategic Roadmap for Accelerated Adoption of Automated Vehicles (AVs)



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This report includes the final Automated Vehicle Pooled Fund Study (AV PFS) Program Roadmap and Program Plan, built upon a previous report on the State of the Practice (SOP).

16. Abstract

The Automated Vehicle Pooled Fund Study (AV PFS) commissioned the development of the Infrastructure Owner Operator (IOO) Strategic Roadmap for Accelerated Adoption of AVs Project to consolidate guidance and identify programs that support the ability for IOOs to nationally move forward towards integrating AVs into the surface transportation ecosystem. Currently, there is a lack of unified national guidance on effective and consistent AV programming. As the AV PFS further analyzes the pillars and programs identified within this roadmap, it may provide better leadership nationally in the spectrum of AV technology challenges and collaboration with the AV industry. This Program Roadmap is a partner to the Program Plan, which identifies Programs that may be taken on to accelerate the adoption of AVs. The Roadmap identifies Program Milestones, or key accomplishments, that realize progress towards the ultimate goal of the Program.

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AUTOMATED VEHICLE POOLED FUND STUDY

Infrastructure Owner Operators Strategic Roadmap for Accelerated Adoption of Automated Vehicles

Program Roadmap

Contents

Introduction

State departments of transportation (DOTs) and infrastructure owner operators (IOOs) can play a notable part in facilitating efforts to advance automated vehicle (AV) technologies and maximizing their potential benefits. While the promises of AV technology represent a significant opportunity for IOOs, long-term success will depend on IOO investments toward the right strategies and initiatives. Over the past decade, a multitude of AV-focused special interest committees, groups and partnerships, across government, industry and academic sectors, have emerged to support AV testing and deployment. Many of these groups are engaging in meaningful efforts to generate work products that target specific needs, questions and challenges around AV deployment; however, a more coordinated and aligned effort among the public and private sectors is necessary to allow the Automated Vehicle Pooled Fund Study (AV PFS) to focus its efforts on challenges not currently being addressed by other projects. This effort aims to identify the current challenges and organize them into specific categories to better allow for alignment and awareness of AV activities at the national level.

Purpose of the Roadmap

The Automated Vehicle Pooled Fund Study (AV PFS) commissioned the development of the ***IOO Strategic Roadmap for Accelerated Adoption of AVs*** project to consolidate guidance and identify Programs that support the ability for IOOs to nationally move forward towards integrating AVs into the surface transportation ecosystem. Currently, there is a lack of unified national guidance on effective and consistent AV programming. As the AV PFS further analyzes the pillars and programs identified within this roadmap, it may provide better ***leadership nationally in the spectrum of AV technology challenges and collaboration with the AV industry.*** This Program Roadmap is a partner to the Program Plan attached in the appendix, which identifies Programs that may be taken on to accelerate the adoption of AVs. The Roadmap identifies Program Milestones, or key accomplishments, that realize progress towards the ultimate goal of the Program.

VISION: Identify Programs that support that ability for IOOs to integrate AVs into the surface transportation system.

The **OBJECTIVES** for this Roadmap are to:

- Identify Milestones for Program
- Identify the Milestone dependencies and connections across Programs
- Support the development of complementary Projects that meet shared AV goals

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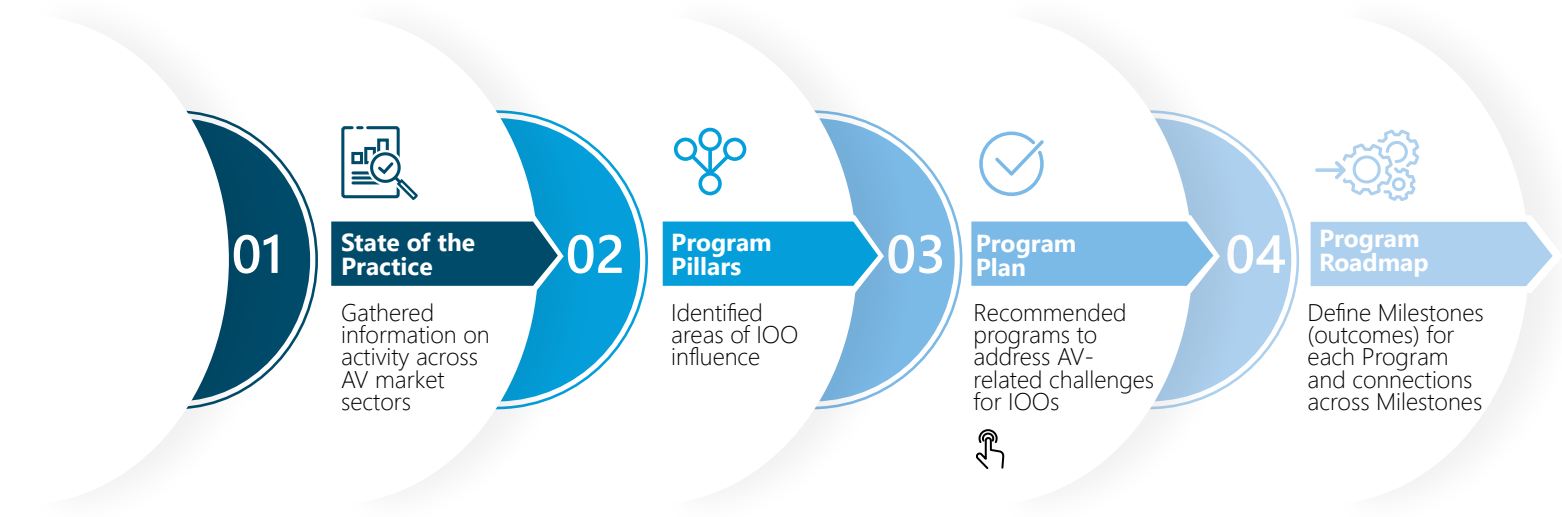
Roadmap Development

This project was initiated with the development of a ***State of the Practice***. The State of the Practice provides an analysis of the primary AV market sectors: passenger, goods movement and transit, and market sector activity across testing, pilot, and deployment stages. Subsequently, AV PFS members helped develop the ***Program Plan*** and ***Program Roadmap*** that identify focus areas that can be influenced by IOOs (***Program Pillars***) and Program goals that address the foremost AV-related challenges and needs for IOOs. The ***Program Roadmap*** provides Milestones that indicate progress towards achieving each Program, as well as the interdependencies across Milestones.



How to Read this Roadmap

SECTION A

Program Recommendations Summary

The Program Recommendations Summary provides a brief description of each Program by Pillar and its relative priority, as identified by AV PFS members. There are seven Pillars, each highlighting the target areas of IOO influence for AV initiatives. Program Pillars are as follows:

Physical and Digital Infrastructure Readiness: The physical and digital environments that enable or enhance AVs

Operations: Potential AV opportunities for day-to-day DOT functions

Interstate Freight and Multi-Modal Harmonization: Considerations for cross-state multi-modal AV travel

Partnerships: The pursuit of sustained partnerships

Workforce: Internal and/or external skill development support

Communications and Engagement: Targeted outreach and communications

Policy: Regulations and standardization that support AV adoption

A Program is a set of related projects managed in a coordinated manner to obtain benefits not available from managing them individually. These Programs are tactical objectives for each Pillar to help achieve the overall AV PFS vision.

navigate to section

SECTION B

Program Milestones

The Program Milestones provide a set of steps for each Program and a depiction of Milestone connections, dependencies, and high-level sequencing. Milestones describe phases and deliverables that may be undertaken to support the Program development process. Additionally, these Milestones identify crucial outcomes for each Program, including key stakeholder interactions, standards, best practice identification, implementation, and performance measurement.

navigate to section

SECTION C

Network of Program Connections

Each Program addresses a specific need or challenge to accelerating AV adoption. However, many Programs consist of complementary components. A series of Program Connection diagrams is provided to depict key Milestone connections across Programs. These networks illustrate dependencies and opportunities for synergy across Programs.

navigate to section

SECTION D

Potential Projects and Champions

Projects are temporary efforts undertaken to create a unique product, service, or result. An initial set of potential Projects is provided for each Program, which achieve specific aspects of each Program. Projects will be driven by one or more Champion(s) to ensure sustainable support and leadership in executing the Project, leading to effectively managing efforts and maximizing their potential benefits. The expected Project Champion types—IOO, national agency, or coalition—are identified for each Project.

navigate to section

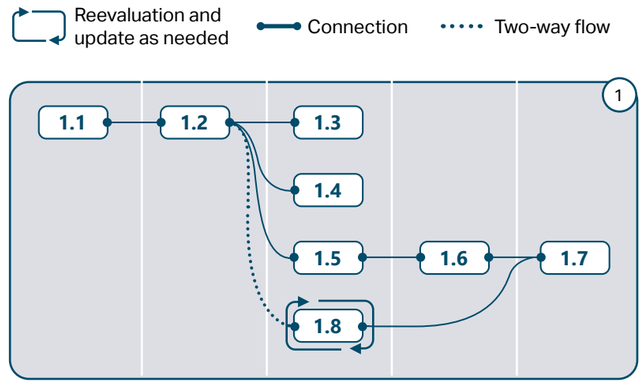
A. Program Recommendations Summary

Pillar	#	Program	Description	Priority
Physical and Digital Infrastructure Readiness	1	Develop and apply control device requirements	Identify physical and digital roadway infrastructure requirement.	High
	2	Develop and implement AV data architecture framework	Develop an IOO/agency data architecture framework that provides a high-level understanding of how AV data will be put to use, with expected data flows, storage needs, etc. Align the architecture framework with the standards and language established by national data exchange initiatives.	Low
	3	Utilize roadway readiness assessment	Coordinate federal, state and industry roadway readiness efforts to support the development of consistent metrics and evaluation methodologies.	High
Operations	4	Integrate AV technologies into traffic operations	Determine implementable use cases for AVs to serve traffic operations (e.g., traffic management and dispatch) to prove potential benefits of the technology to IOOs and travelers.	Low
	5	Integrate AV technologies into maintenance and construction activities	Determine implementable use cases for AVs support maintenance and construction (e.g., automated crash attenuator vehicles, automated snowplows) to prove potential benefits of the technology to IOO workforce.	Medium
Interstate Freight and Multi-Modal Harmonization	6	Identify national AV freight corridors	Identify interstate corridors that are ready to support AV freight travel and communicate AV corridor locations to the industry.	Medium
	7	Support freight and multi-modal data exchange initiatives	Identify freight/multi-modal AV data sharing use cases to support continued improvement of existing data exchanges and the potential creation of additional data initiatives, as needed.	Low
	8	Use AV technologies to support first/last mile connectivity	Identify first/last mile issues and potential AV solutions for freight (e.g., port operations) and multi-modal travel.	Low
Partnerships	9	Facilitate sustained IOO-industry partnership	Sustain regular engagement of AV industry and IOOs to facilitate mutually beneficial information exchange and possible collaboration on work products.	High
	10	Engage in ongoing safety standardization efforts	Participate in efforts led by various standardization groups to inform the development of feasible safety standards for ADS-equipped vehicles that can be met in real world environments.	Medium
	11	Facilitate sustained partnership with public safety officials to share AV deployment information	Establish recommended communication process and reporting needs for industry and IOOs to share AV testing and deployment activity information with public safety officials.	Medium
Workforce	12	Prepare IOO organization and workforce for a transportation system that integrates AVs	Adopt flexible practices that support workforce adaptability and expansion, including robust workforce education programs to foster skills growth.	Medium
Communications and Engagement	13	Deploy and support public education efforts	Develop educational materials and mechanisms to address gaps in public knowledge and misconceptions that may lead to hesitancy or skepticism.	Medium
	14	Communicate with policy makers to provide input that informs legislation	Maintain two-way communication with policy makers to provide the latest AV information (e.g., innovations, issues, etc.) and review regulatory progress.	Medium
Policy	15	Participate in the development of common Law Enforcement Interaction Protocols (LEIPs)	Consolidate LEIP guidelines, across industry and associations, and identify best practice LEIPs to support common, widespread adoption and encourage the industry to respond to desired interaction needs.	Medium
	16	Facilitate compatibility between federal, state and local motor vehicle regulations	Participate in developing a framework that unifies best practices for AV licensing, registration, and insurance to support seamless transition of AVs between jurisdictions.	Medium

B. Program Milestones

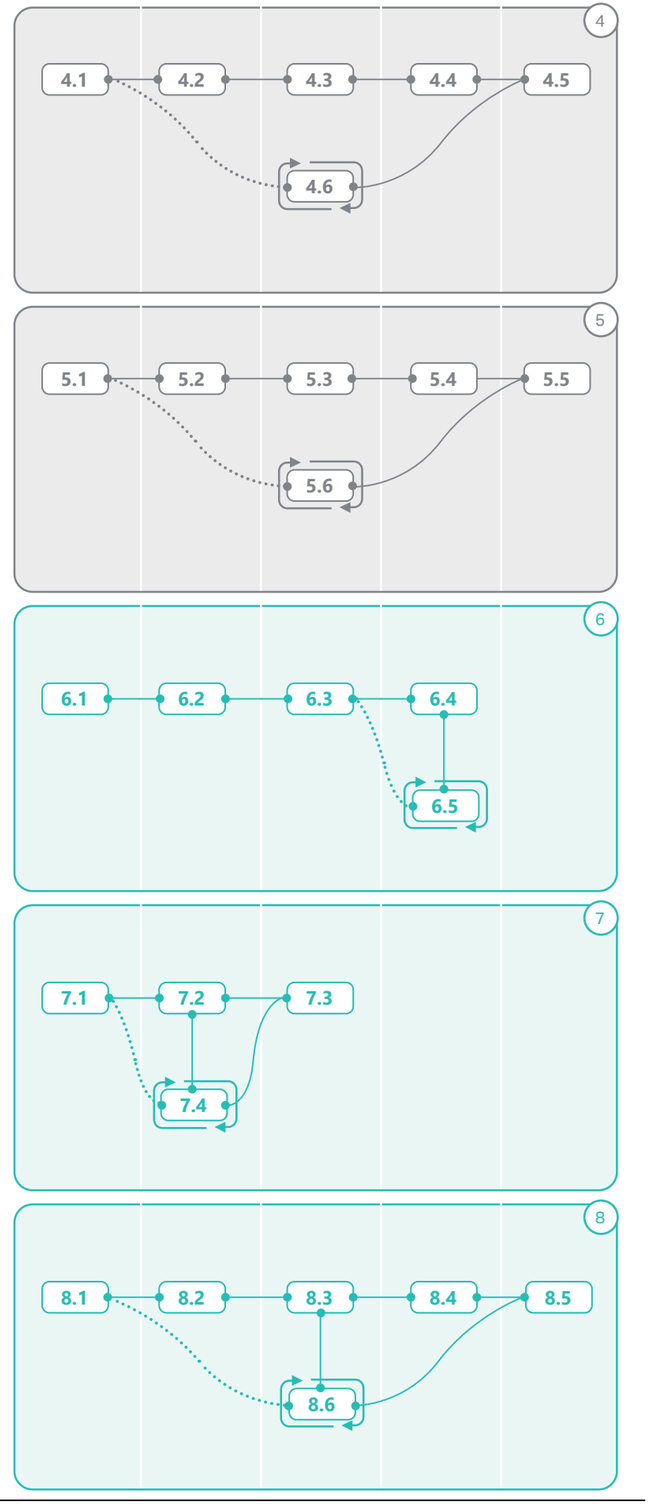
Pillar	#	Program	ID	Milestone
Infrastructure Readiness	1	Deploy and apply control device requirements click for more information	1.1	Inventory of physical and digital **infrastructure component and maintenance needs** are identified
			1.2	Reasonable **baseline requirements** are determined by infrastructure component
			1.3	Infrastructure component **standards are updated** to incorporate requirements
			1.4	Infrastructure **maintenance practices/programs** are updated to incorporate requirements
			1.5	Infrastructure component **gap analysis** is conducted to compare requirements with the current state
			1.6	**Implementation plans** are developed to identify steps and phasing for infrastructure component modifications
			1.7	Existing infrastructure components are upgraded to **meet requirements**
			1.8	A mechanism to **reevaluate** baseline requirements and O&M needs upon significant technology advancement is implemented
	2	Develop and implement AV data architecture framework click for more information	2.1	The **data industry and subject matter experts are engaged** to identify useful, beneficial data that could be exchanged between AVs and IOOs
			2.2	A scalable **data architecture framework** is developed, which includes high-level data flows, integration and storage needs to support AV data use cases
			2.3	**Systems engineering analysis** is performed to plan for data architecture modifications and testing
			2.4	Data governance **policies and processes are updated** to support the AV data architecture
			2.5	Data **architecture updates are implemented**
			2.6	A mechanism for **performance reevaluation** and improvement of the architecture is implemented
	3	Utilize roadway readiness assessment click for more information	3.1	Complementary roadway readiness **efforts are coordinated** among IOOs, industry and standardization bodies to ensure consistency and avoid duplication
			3.2	Roadway infrastructure component **characteristics that support ADS** features, by environment (operational design domain), are identified
			3.3	A **unified AV roadway readiness assessment framework** with metrics and methodology is identified for widespread use
			3.4	AV roadway readiness **assessment is incorporated into planning processes** and long-range planning efforts
			3.5	A mechanism to **reevaluate** and improve the AV roadway readiness assessment framework upon significant technology advancement is implemented

Interdependencies Roadmap



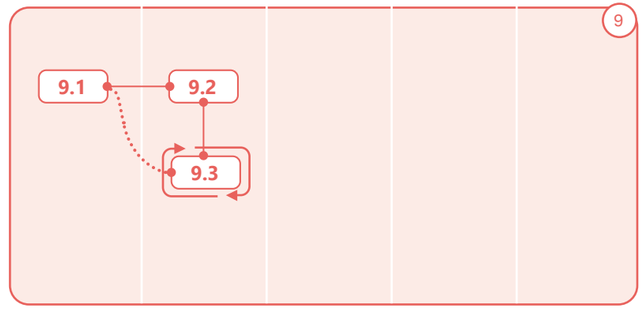
Pillar	#	Program	ID	Milestone
Operations	4	Integrate AV technologies into traffic operations click for more information	4.1	**Goals and use cases** for AV application to traffic operations are identified in collaboration with IOOs and industry
			4.2	Traffic operations **use cases are prioritized** based on potential feasibility, benefits and cost
			4.3	Traffic operations **projects are developed** to address priority use cases with clear goals, performance metrics and implementation plan
			4.4	AV traffic operations **projects are executed**
			4.5	**Performance measurement** is routinely conducted to determine the effects of AV technology application to traffic operations
			4.6	A mechanism to **reevaluate** use cases for emerging AV technology and traffic operations is implemented to support organizational agility and adaptability
	5	Integrate AV technologies into maintenance and construction activities click for more information	5.1	**Goals and use cases** for AV application to maintenance and construction are identified in collaboration with IOOs and industry
			5.2	Maintenance and construction **use cases are prioritized** based on potential feasibility, benefits and cost
			5.3	Maintenance/construction **projects are developed** to address priority use cases with clear goals, performance metrics and implementation plan
			5.4	Identified AV maintenance and construction **projects are executed**
			5.5	**Performance measurement** is routinely conducted to determine the effects of AV technology application to maintenance and construction
			5.6	A mechanism to **reevaluate** emerging AV technology goals and maintenance/construction use cases is implemented to support organizational agility and adaptability
Interstate Freight and Multi-Modal Harmonization	6	Identify national AV freight corridors click for more information	6.1	AV freight **corridor criteria are identified** in collaboration with industry and in alignment with roadway readiness assessment framework
			6.2	Regulatory **barriers are identified and adjusted**, in accordance with the AV regulatory framework
			6.3	Criteria are applied to facilities and AV freight ready **corridors are designated**
			6.4	A mechanism for **tracking national AV freight corridor** activity is implemented
			6.5	A mechanism to **expand or modify** AV freight corridor designations is implemented
	7	Support freight and multi-modal data exchange initiatives click for more information	7.1	**Goals and use cases** for freight and multi-modal data exchange are identified in partnership with multi-modal IOOs
			7.2	**Data exchanges** are identified, as needed, to ensure AV operations information sharing and support use cases
			7.3	Freight and multi-modal **data exchanges are implemented**
			7.4	A mechanism to **reevaluate and continuously improve** the national network of information sharing is implemented
	8	Use AV technologies to support first/last mile connectivity click for more information	8.1	**Goals and use cases** for AV application to first/last mile connectivity are identified in collaboration with IOOs and industry
			8.2	First/last mile **use cases are prioritized** based on potential feasibility, benefits and cost
			8.3	First/last mile **projects are developed** to address priority use cases with clear goals and performance metrics
			8.4	Identified AV first/last mile **projects are executed**
			8.5	**Performance measurement** is routinely conducted to determine the effects of AV technology application to first/last mile connectivity
			8.6	A mechanism to **reevaluate** emerging AV technology goals and first/last mile use cases is developed to support organizational agility and adaptability

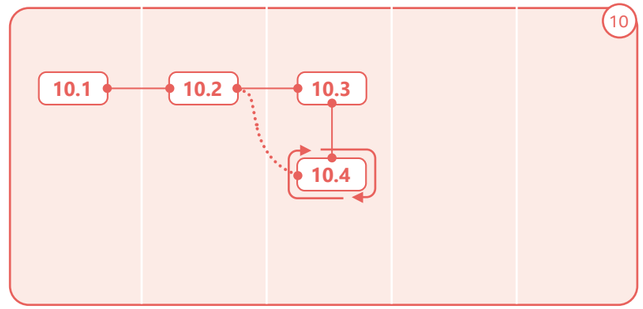
Interdependencies Roadmap

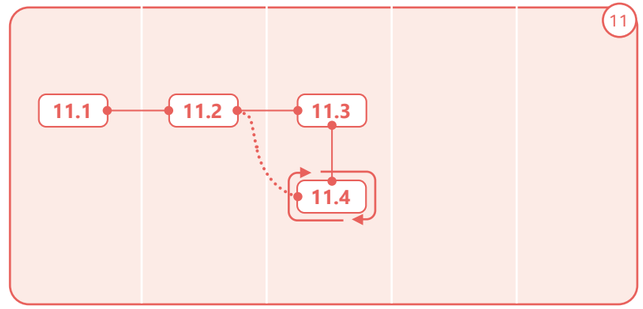


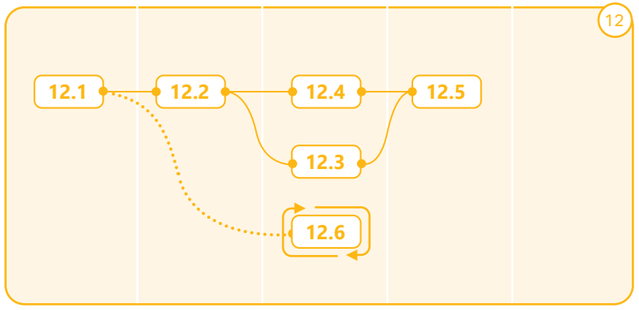
Pillar	#	Program	ID	Milestone
Partnerships	9	Facilitate sustained IOO-industry partnership click for more information	9.1	**Goals for a sustained partnership** among IOOs and industry are identified
			9.2	A **venue or forum** for sustained IOO-industry communication and partnership is established
			9.3	A mechanism to **continuously gather feedback**, measure performance and make adjustments to the IOO-industry venue is implemented
	10	Engage in ongoing safety standardization efforts click for more information	10.1	**Goals for the safe operation** of AVs on public roadways are identified in coordination with standardization bodies, IOOs and industry
			10.2	**Safety standards** are developed for ADS-equipped vehicles
			10.3	A mechanism for **enforcing** ADS-equipped vehicle safety standards is developed and implemented
			10.4	A mechanism to **reevaluate and continuously improve** ADS-equipped vehicle safety standards is implemented
	11	Facilitate sustained partnership with public safety officials to share AV deployment information click for more information	11.1	A **State or local agency forum** for sustained communication among IOOs and public safety agencies is developed to exchange information on current AV technology deployments, regulations, protocols for interaction with pubic safety vehicles and public views on AVs
			11.2	AV testing and deployment **communication and reporting needs** for public safety agencies are identified and integrated
			11.3	Public safety agencies **routinely share AV information** with the general public, as appropriate, to address areas of concern and demonstrate the normalization of AV travel
			11.4	A mechanism to **continuously measure performance** and make adjustments to communication processes and reporting standards is implemented
Workforce	12	Prepare IOO organization and workforce for a transportation system that integrates AVs click for more information	12.1	**Objectives** for workforce AV education are identified that support continued skills growth and adaptability
			12.2	An **assessment of current AV technology knowledge** and resource availability is conducted to inform the development of educational content
			12.3	An **assessment of current workforce education programs** is conducted to identify systemic modifications that may be needed to support workforce adaptability
			12.4	Workforce education programs and **materials are updated and deployed** to support skills required for new technologies
			12.5	Educational **materials are provided to trade schools/community colleges** to inform technology education courses
			12.6	A mechanism to **continuously measure workforce education program** performance and make adjustments is implemented

Interdependencies Roadmap



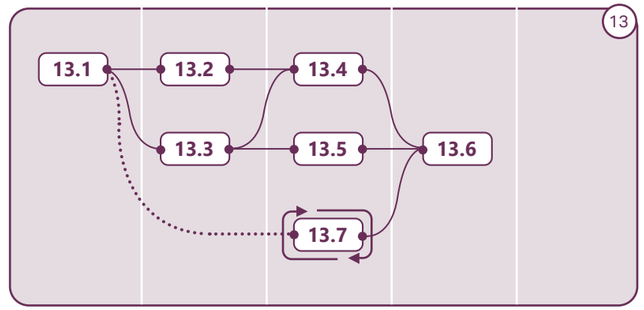


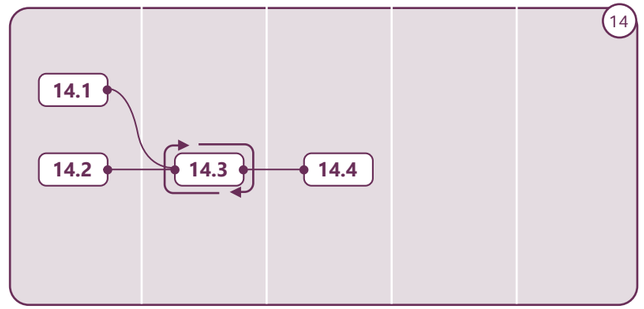


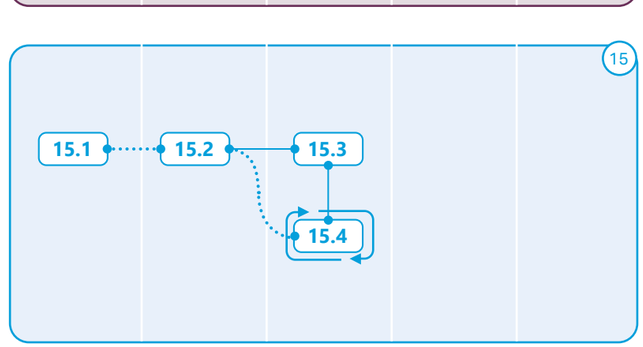


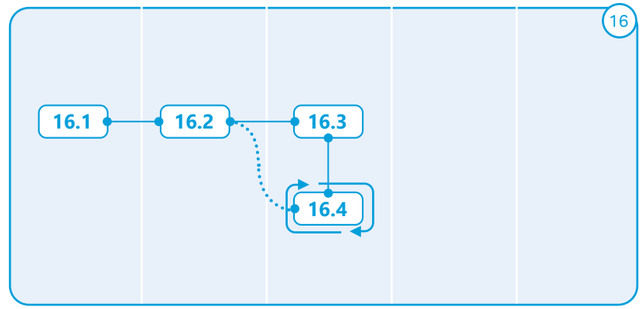
Pillar	#	Program	ID	Milestone
Communications and Engagement	13	Deploy and support public education efforts click for more information	13.1	A **forum for communication** among State and local agencies and organizations is implemented to exchange information on public education needs, materials and outcomes
			13.2	**Gaps** in public knowledge and barriers to acceptance are identified
			13.3	**Early target user groups** for AVs technologies are identified, with highest benefit potential
			13.4	Public education **primers and communication templates** are developed and shared with State and local partners
			13.5	**Venues for communicating AV information**, including existing events with access to target user groups, are identified
			13.6	**Public education** on AV technology is provided
			13.7	A mechanism to **continuously measure performance** of public sentiment and AV public education efforts is implemented
	14	Communicate with policy makers to provide input that informs legislation click for more information	14.1	A **summary** of State and local AV activity, issues and public education efforts is compiled and routinely shared with policy makers
			14.2	Brief, high-level **updates on current AV innovations** and potential regulatory implications, if any, are prepared and routinely shared with policy makers
			14.3	Draft motor vehicle **regulations are shared with IOOs** for review and input
			14.4	**Motor vehicle regulations** that facilitate AV adoption are adopted
Policy	15	Participate in the development of common Law Enforcement Interaction click for more information	15.1	Existing LEIP guidelines from industry (Cruise, Nuro, Waymo) and associations (AAMVA) are **compiled and compared** with law enforcement officers local laws and regulations to determine distinctions and gaps that should be addressed
			15.2	**Best practice LEIPs are identified** by public safety agencies in coordination with IOOs, national agencies and industry
			15.3	Common **LEIPs are adopted** by State and local jurisdictions
			15.4	A mechanism for routine **evaluation and update** of LEIPs is established
	16	Facilitate compatibility between federal, state and local motor vehicle regulations click for more information	16.1	Existing ADS motor vehicle regulations and practices across States and jurisdictions are **compiled and compared** to determine distinctions and gaps that should be addressed
			16.2	**Framework** for ADS motor vehicle regulations is identified by public safety agencies in coordination with IOOs and industry
			16.3	**Updates** to State and local motor vehicle regulations, in accordance with the AV motor vehicle regulation framework, are adopted
			16.4	A mechanism for **evaluating regulations and practices** upon significant technology advancement and making adjustments is established

Interdependencies Roadmap



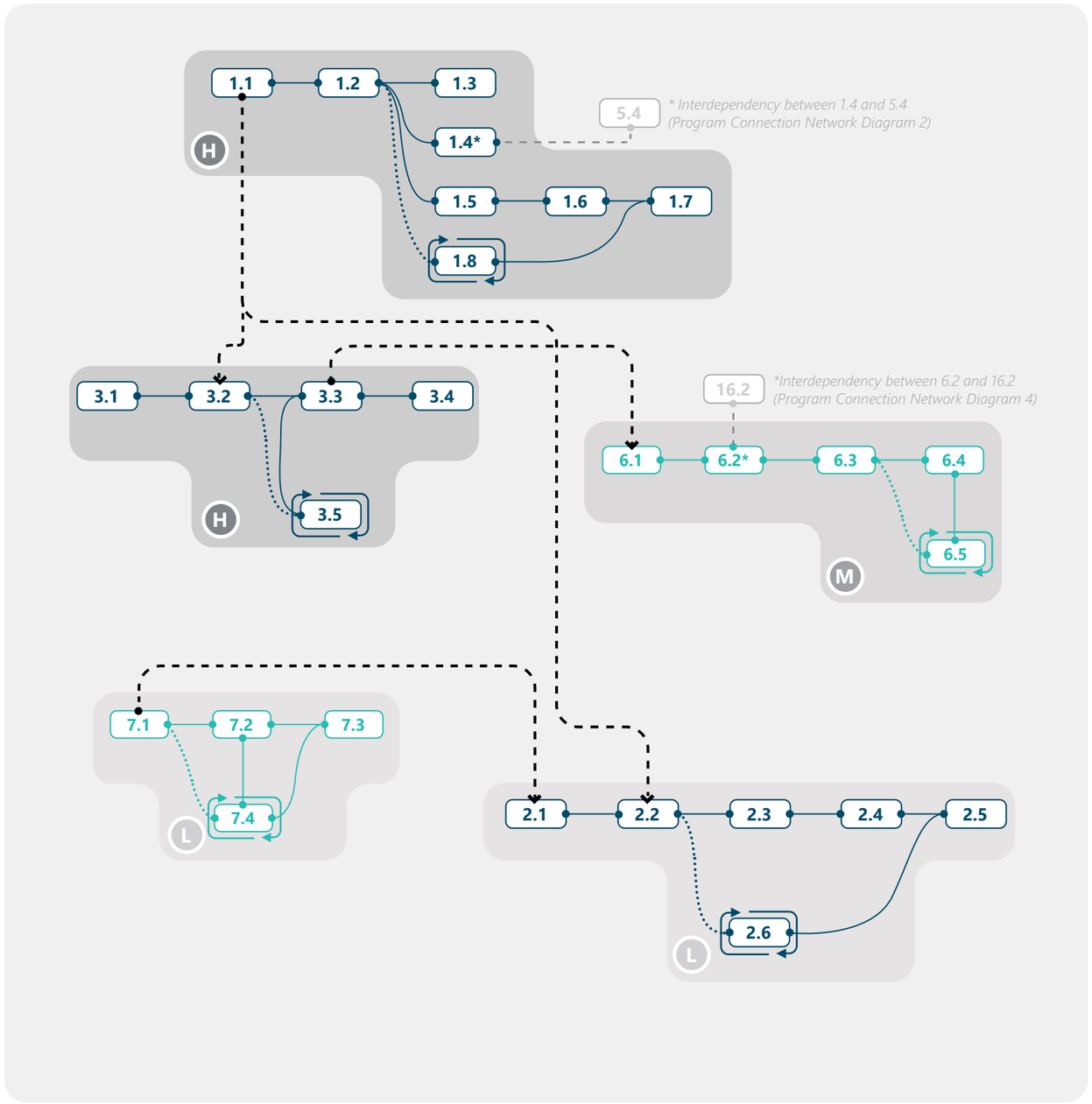






C. Program Connection Networks

1. Key Interdependencies Enabling Infrastructure Requirements and Readiness Assessment

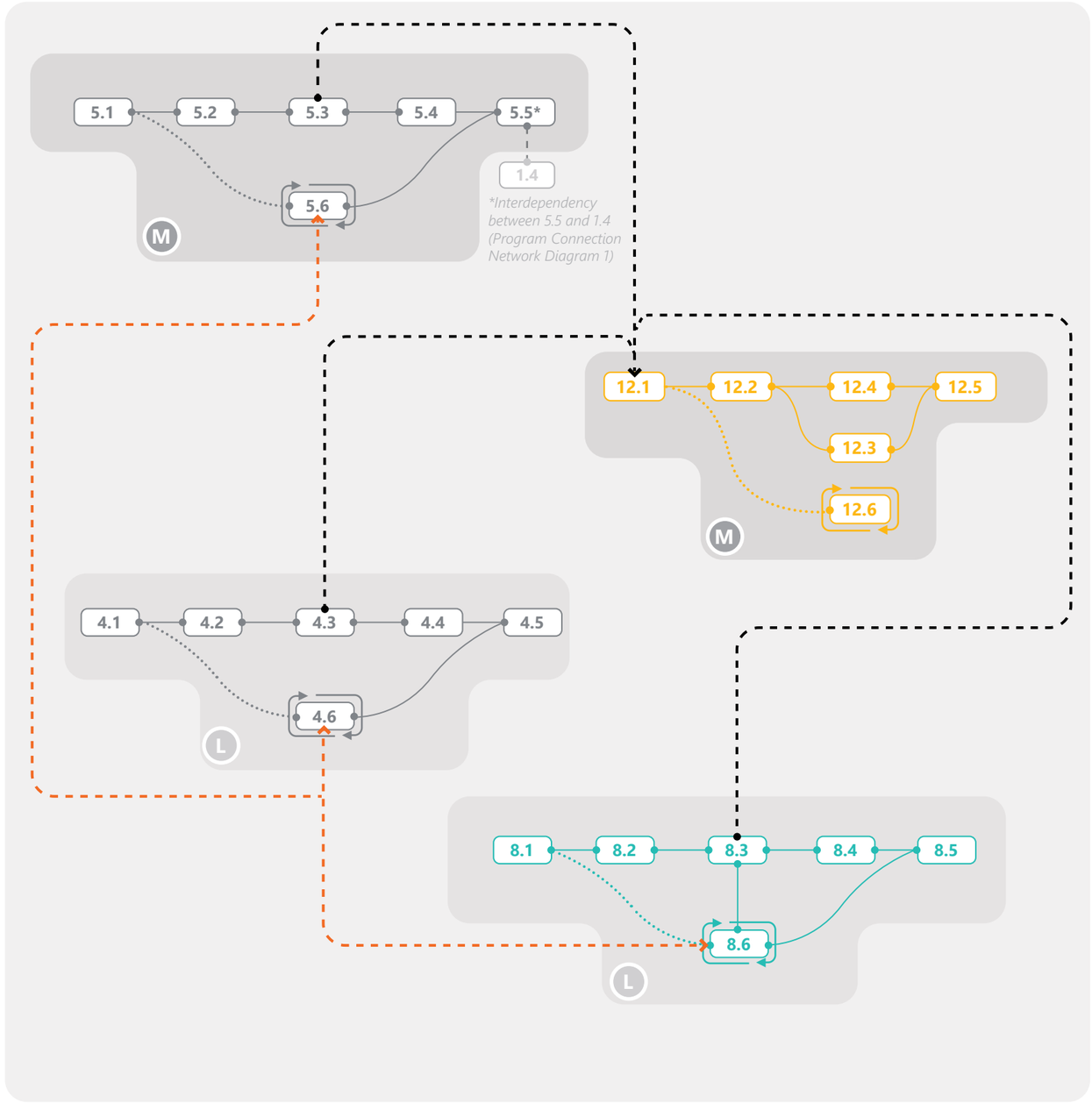


Reevaluation and update as needed — Connection — Two-way flow — Connections across Programs

H High Priority Program M Medium Priority Program L Low Priority Program

Pillar	#	Program	ID	Milestone
Infrastructure Readiness	1	Deploy and apply control device requirements	1.1	Inventory of physical and digital infrastructure component and maintenance needs are identified
			1.2	Reasonable baseline requirements are determined by infrastructure component
			1.3	Infrastructure component standards are updated to incorporate requirements
			1.4	Infrastructure maintenance practices/programs are updated to incorporate requirements
			1.5	Infrastructure component gap analysis is conducted to compare requirements with the current state
			1.6	Implementation plans are developed to identify steps and phasing for infrastructure component modifications
			1.7	Existing infrastructure components are upgraded to meet requirements
			1.8	A mechanism to reevaluate baseline requirements and O&M needs upon significant technology advancement is implemented
	2	Develop and implement AV data architecture framework	2.1	The data industry and subject matter experts are engaged to identify useful, beneficial data that could be exchanged between AVs and IOOs
			2.2	A scalable data architecture framework is developed, which includes high-level data flows, integration and storage needs to support AV data use cases
			2.3	Systems engineering analysis is performed to plan for data architecture modifications and testing
			2.4	Data governance policies and processes are updated to support the AV data architecture
			2.5	Data architecture updates are implemented
			2.6	A mechanism for performance measurement and improvement of the architecture is implemented
	3	Utilize roadway readiness assessment	3.1	Complementary roadway readiness efforts are coordinated among IOOs, industry and standardization bodies to ensure consistency and avoid duplication
			3.2	Roadway infrastructure component characteristics that support ADS features, by environment (operational design domain), are identified
			3.3	A unified AV roadway readiness assessment framework with metrics and methodology is identified for widespread use
			3.4	AV roadway readiness assessment is incorporated into planning processes and long-range planning efforts
			3.5	A mechanism to reevaluate and improve the AV roadway readiness assessment framework upon significant technology advancement is implemented
Operations	5	Integrate AV technologies into maintenance and construction activities	5.4	Identified AV maintenance and construction projects are executed
Interstate Freight and Multi-Modal Harmonization	6	Identify national AV freight corridors	6.1	AV freight corridor criteria are identified in collaboration with industry and in alignment with roadway readiness assessment framework
			6.2	Regulatory barriers are identified and adjusted, in accordance with the AV regulatory framework
			6.3	Criteria are applied to facilities and AV freight ready corridors are designated
			6.4	A mechanism for tracking national AV freight corridor activity is implemented
			6.5	A mechanism to expand or modify AV freight corridor designations is implemented
	7	Support freight and multi-modal data exchange initiatives	7.1	Goals and use cases for freight and multi-modal data exchange are identified in partnership with multi-modal IOOs
			7.2	Data exchanges are identified, as needed, to ensure AV operations information sharing and support use cases
			7.3	Freight and multi-modal data exchanges are implemented
			7.4	A mechanism to reevaluate and continuously improve the national network of information sharing is implemented
Policy	16	Facilitate compatibility between federal, state and local motor vehicle regulations	16.2	Framework for ADS motor vehicle regulations is identified by public safety agencies in coordination with IOOs and industry

2. Key Interdependencies Enabling Organization and Workforce Adaptability

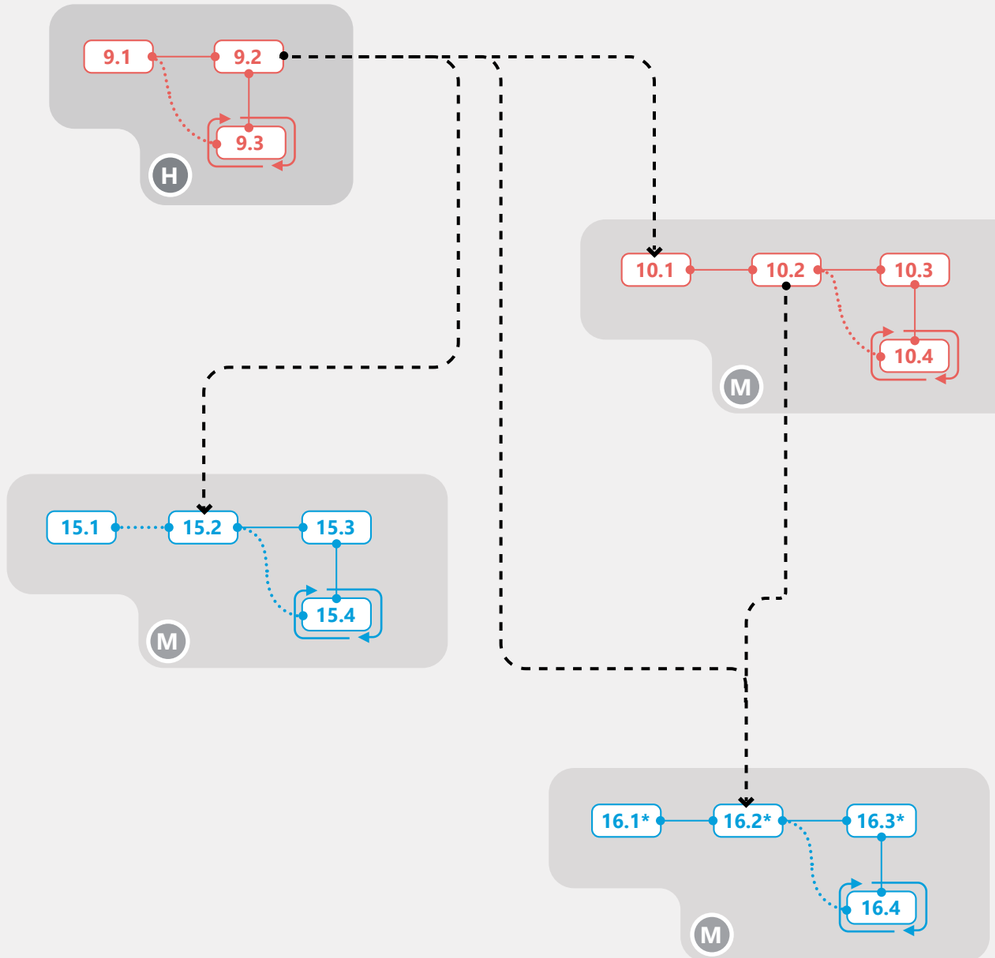


Pillar	#	Program	ID	Milestone
Infrastructure Readiness	1	Deploy and apply control device requirements	1.4	Infrastructure maintenance practices/programs are updated to incorporate requirements
Operations	4	Integrate AV technologies into traffic operations	4.1	Goals and use cases for AV application to traffic operations are identified in collaboration with IOOs and industry
			4.2	Traffic operations use cases are prioritized based on potential feasibility, benefits and cost
			4.3	Traffic operations projects are developed to address priority use cases with clear goals, performance metrics and implementation plan
			4.4	AV traffic operations projects are executed
			4.5	Performance measurement is routinely conducted to determine the effects of AV technology application to traffic operations
			4.6	A mechanism to reevaluate use cases for emerging AV technology and traffic operations is implemented to support organizational agility and adaptability
	5	Integrate AV technologies into maintenance and construction activities	5.1	Goals and use cases for AV application to maintenance and construction are identified in collaboration with IOOs and industry
			5.2	Maintenance and construction use cases are prioritized based on potential feasibility, benefits and cost
			5.3	Maintenance/construction projects are developed to address priority use cases with clear goals, performance metrics and implementation plan
			5.4	Identified AV maintenance and construction projects are executed
			5.5	Performance measurement is routinely conducted to determine the effects of AV technology application to maintenance and construction
			5.6	A mechanism to reevaluate emerging AV technology goals and maintenance/construction use cases is implemented to support organizational agility and adaptability
Interstate Freight and Multi-Modal Harmonization	8	Use AV technologies to support first/last mile connectivity	8.1	Goals and use cases for AV application to first/last mile connectivity are identified in collaboration with IOOs and industry
			8.2	First/last mile use cases are prioritized based on potential feasibility, benefits and cost
			8.3	First/last mile projects are developed to address priority use cases with clear goals and performance metrics
			8.4	Identified AV first/last mile projects are executed
			8.5	Performance measurement is routinely conducted to determine the effects of AV technology application to first/last mile connectivity
			8.6	A mechanism to reevaluate emerging AV technology goals and first/last mile use cases is developed to support organizational agility and adaptability
Workforce	12	Prepare IOO organization and workforce for a transportation system that integrates AVs	12.1	Objectives for workforce AV education are identified that support continued skills growth and adaptability
			12.2	An assessment of current AV technology knowledge and resource availability is conducted to inform the development of educational content
			12.3	An assessment of current workforce education programs is conducted to identify systemic modifications that may be needed to support workforce adaptability
			12.4	Workforce education programs and materials are updated and deployed to support skills required for new technologies
			12.5	Educational materials are provided to trade schools/community colleges to inform technology education courses
			12.6	A mechanism to continuously measure workforce education program performance and make adjustments is implemented

Reevaluation and update as needed — Connection — Two-way flow — Connections across Programs — Opportunity for milestone consolidation across programs

H High Priority Program — M Medium Priority Program — L Low Priority Program

3. Key Interdependencies Enabling National Coordination Efforts



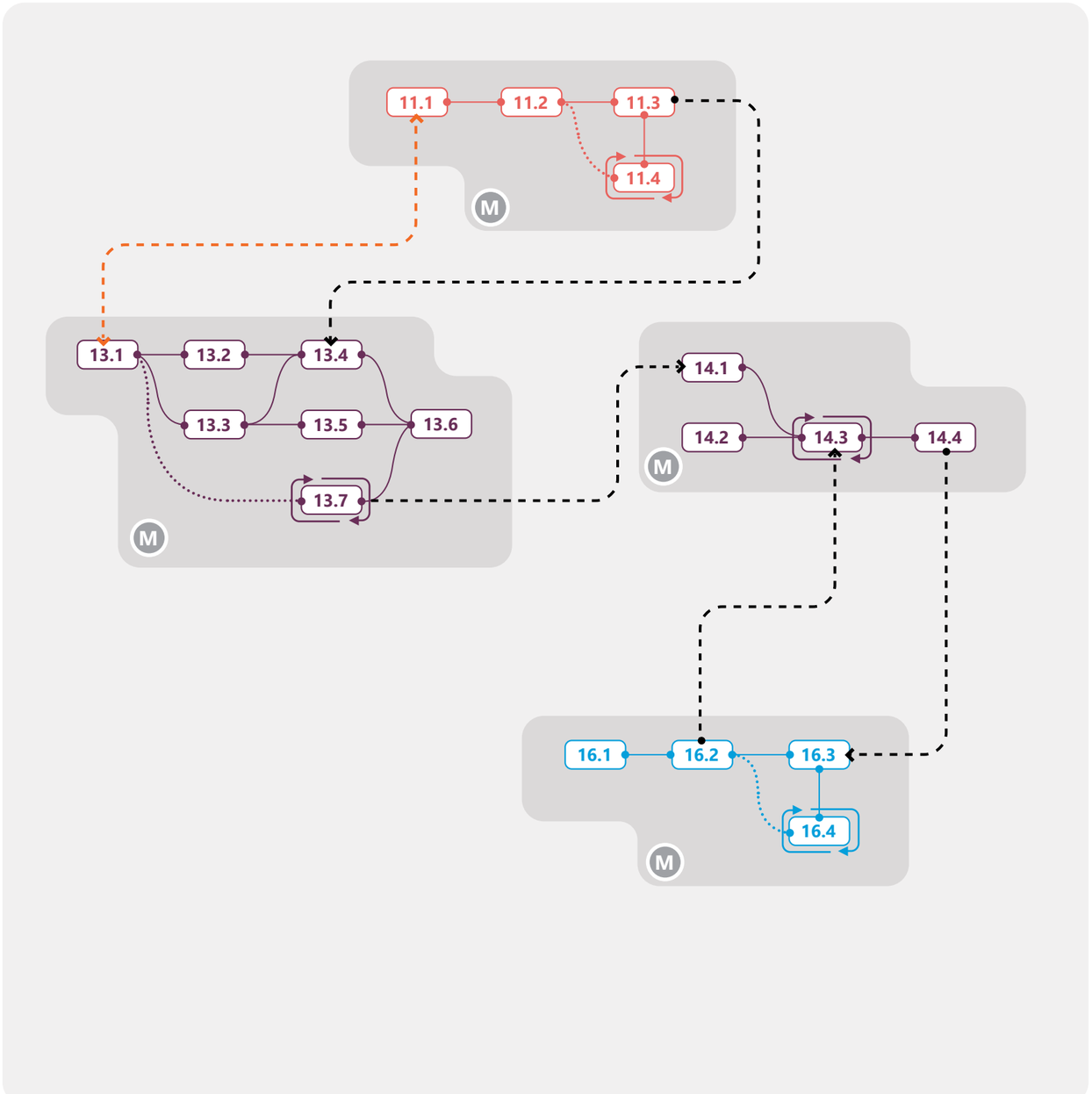
**Interdependency between 16.1, 16.2 and 16.3 (Program Connection Network Diagram 4)*

Pillar	#	Program	ID	Milestone
Partnerships	9	Facilitate sustained IOO-industry partnership	9.1	Goals for a sustained partnership among IOOs and industry are identified
			9.2	A venue or forum for sustained IOO-industry communication and partnership is established
			9.3	A mechanism to continuously gather feedback, measure performance and make adjustments to the IOO-industry venue is implemented
	10	Engage in ongoing safety standardization efforts	10.1	Goals for the safe operation of AVs on public roadways are identified in coordination with standardization bodies, IOOs and industry
			10.2	Safety standards are developed for ADS-equipped vehicles
			10.3	A mechanism for enforcing ADS-equipped vehicle safety standards is developed and implemented
			10.4	A mechanism to reevaluate and continuously improve ADS-equipped vehicle safety standards is implemented
Communications and Engagement	13	Deploy and support public education efforts	13.1	A forum for communication among State and local agencies and organizations is implemented to exchange information on public education needs, materials and outcomes
			13.2	Gaps in public knowledge and barriers to acceptance are identified
			13.3	Early target user groups for AVs technologies are identified, with highest benefit potential
			13.4	Public education primers and communication templates are developed and shared with State and local partners
			13.5	Venues for communicating AV information, including existing events with access to target user groups, are identified
			13.6	Public education on AV technology is provided
			13.7	A mechanism to continuously measure performance of public sentiment and AV public education efforts is implemented
Policy	15	Participate in the development of common Law Enforcement Interaction	15.1	Existing LEIP guidelines from industry (Cruise, Nuro, Waymo) and associations (AAAMVA) are compiled and compared with law enforcement officers local laws and regulations to determine distinctions and gaps that should be addressed
			15.2	Best practice LEIPs are identified by public safety agencies in coordination with IOOs, national agencies and industry
			15.3	Common LEIPs are adopted by State and local jurisdictions
			15.4	A mechanism for routine evaluation and update of LEIPs is established
	16	Facilitate compatibility between federal, state and local motor vehicle regulations	16.1	Existing ADS motor vehicle regulations and practices across States and jurisdictions are compiled and compared to determine distinctions and gaps that should be addressed
			16.2	Framework for ADS motor vehicle regulations is identified by public safety agencies in coordination with IOOs and industry
			16.3	Updates to State and local motor vehicle regulations, in accordance with the AV motor vehicle regulation framework, are adopted
			16.4	A mechanism for evaluating regulations and practices upon significant technology advancement and making adjustments is established

Reevaluation and update as needed — Connection — Two-way flow — Connections across Programs

H High Priority Program — M Medium Priority Program — L Low Priority Program

4. Key Interdependencies Enabling State and Local Coordination Efforts



Pillar	#	Program	ID	Milestone
Partnerships	11	Facilitate sustained partnership with public safety officials to share AV deployment information	11.1	A State or local agency forum for sustained communication among IOOs and public safety agencies is developed to exchange information on current AV technology deployments, regulations, protocols for interaction with pubic safety vehicles and public views on AVs
			11.2	AV testing and deployment communication and reporting needs for public safety agencies are identified and integrated
			11.3	Public safety agencies routinely share AV information with the general public, as appropriate, to address areas of concern and demonstrate the normalization of AV travel
			11.4	A mechanism to continuously measure performance and make adjustments to communication processes and reporting standards is implemented
Communications and Engagement	13	Deploy and support public education efforts	13.1	A forum for communication among State and local agencies and organizations is implemented to exchange information on public education needs, materials and outcomes
			13.2	Gaps in public knowledge and barriers to acceptance are identified
			13.3	Early target user groups for AVs technologies are identified, with highest benefit potential
			13.4	Public education primers and communication templates are developed and shared with State and local partners
			13.5	Venues for communicating AV information, including existing events with access to target user groups, are identified
			13.6	Public education on AV technology is provided
			13.7	A mechanism to continuously measure performance of public sentiment and AV public education efforts is implemented
	14	Communicate with policy makers to provide input that informs legislation	14.1	A summary of State and local AV activity, issues and public education efforts is compiled and routinely shared with policy makers
			14.2	Brief, high-level updates on current AV innovations and potential regulatory implications, if any, are prepared and routinely shared with policy makers
			14.3	Draft motor vehicle regulations are shared with IOOs for review and input
			14.4	Motor vehicle regulations that facilitate AV adoption are adopted
Policy	16	Facilitate compatibility between federal, state and local motor vehicle regulations	16.1	Existing ADS motor vehicle regulations and practices across States and jurisdictions are compiled and compared to determine distinctions and gaps that should be addressed
			16.2	Framework for ADS motor vehicle regulations is identified by public safety agencies in coordination with IOOs and industry
			16.3	Updates to State and local motor vehicle regulations, in accordance with the AV motor vehicle regulation framework, are adopted
			16.4	A mechanism for evaluating regulations and practices upon significant technology advancement and making adjustments is established

Reevaluation and update as needed — Connection — Two-way flow — Connections across Programs — Opportunity for milestone consolidation across programs

H High Priority Program — M Medium Priority Program — L Low Priority Program

D. Potential Projects and Champions

	Program	Potential Projects	IOO	Federal Agency	Coalition
1	Deploy and apply control device requirements	ADS work zone requirements development		✓	✓
		ADS striping requirements development		✓	✓
		ADS signing requirements development		✓	✓
		IOO-industry mapping requirements development	✓		
2	Develop and implement AV data architecture framework	Data security requirements	✓	✓	
		Data storage and reporting requirements	✓		
		AV data architecture systems engineering analysis	✓		
3	Utilize roadway readiness assessment	Roadway readiness assessment of priority corridors	✓	✓	
		Roadway readiness mapping visualization	✓		
4	Integrate AV technologies into traffic operations	AV monitoring of static assets	✓		
		AV monitoring of roadway conditions	✓		
		Automated bus deployment	✓	✓	✓
5	Integrate AV technologies into maintenance and construction activities	Automated snow plow deployment	✓		
		Automated crash attenuator deployment	✓		
6	Identify national AV freight corridors	National AV freight corridor readiness assessment		✓	✓
		National AV freight corridor visualization		✓	✓
7	Support freight and multi-modal data exchange initiatives	AV freight/multi-modal use case development	✓		✓
8	Use AV technologies to support first/last mile connectivity	Automated stacking cranes deployment at ports	✓		
		AV microtransit deployment	✓		
9	Facilitate sustained IOO-industry partnership	AV IOO-industry forum			✓
10	Engage in ongoing safety standardization efforts	ADS safety standards		✓	✓
		ADS safety enforcement best practices		✓	✓
11	Facilitate sustained partnership with public safety officials to share AV deployment information	IOO-public safety official forum	✓		
		AV safety reports		✓	✓
12	Prepare IOO organization and workforce for a transportation system that integrates AVs	Workforce education program update roadmap	✓		✓
		Workforce education program deployment	✓		✓
13	Deploy and support public education efforts	AV public education communication strategy	✓		✓
14	Communicate with policy makers to provide input that informs legislation	National AV policy guidelines		✓	✓
15	Participate in the development of common Law Enforcement Interaction Protocols (LEIPs)	LEIP best practices	✓		✓
16	Facilitate compatibility between federal, state and local motor vehicle regulations	AV licensing guidelines		✓	✓
		AV registration guidelines		✓	✓
		AV insurance guidelines		✓	✓

Next Steps

The Program Plan and Roadmap collectively lay the foundation for developing specific initiatives to accelerate the adoption of AVs across IOO areas of focus. The seven Program Pillars and sixteen Programs identified herein provide wide-ranging objectives that intend to guide thoughtful, strategic investments in AV initiatives. Program Milestones and Projects aim to break down incremental efforts that may be taken to achieve each Program.

Top Projects for high-priority programs, which may be considered for immediate action include:

- ADS work zone requirements development
- ADS striping requirements development
- ADS signing requirements development
- IOO-industry mapping requirements development
- Roadway readiness assessment of priority corridors
- Roadway readiness mapping visualization
- AV IOO-Industry Forum

The Programs presented in the Roadmap may be used to coordinate future AV efforts with other organizations and IOOs. As the landscape of AV technology and policy continues to evolve, Programs and Projects may be expanded or adapted to address the latest developments.

Appendix:
Program Plan

Background

Overview

Automated Vehicles (AVs) are an emerging, "disruptive" transportation technology that has demonstrated the potential to reduce crashes and fatalities on our nation's transportation networks. State Departments of Transportation (DOTs) and infrastructure owner operators (IOOs) can play a notable part in facilitating efforts to advance AV technologies and maximizing their potential benefits. The Automated Vehicle Pooled Fund Study (AV PFS) was founded in 2020 to provide a means to conduct the research necessary for State DOTs to play their role in **advancing transportation safety and mobility using AVs.**[1]

More specifically, the AV PFS seeks to work with federal and state departments of transportation and infrastructure owner operators to implement projects that:

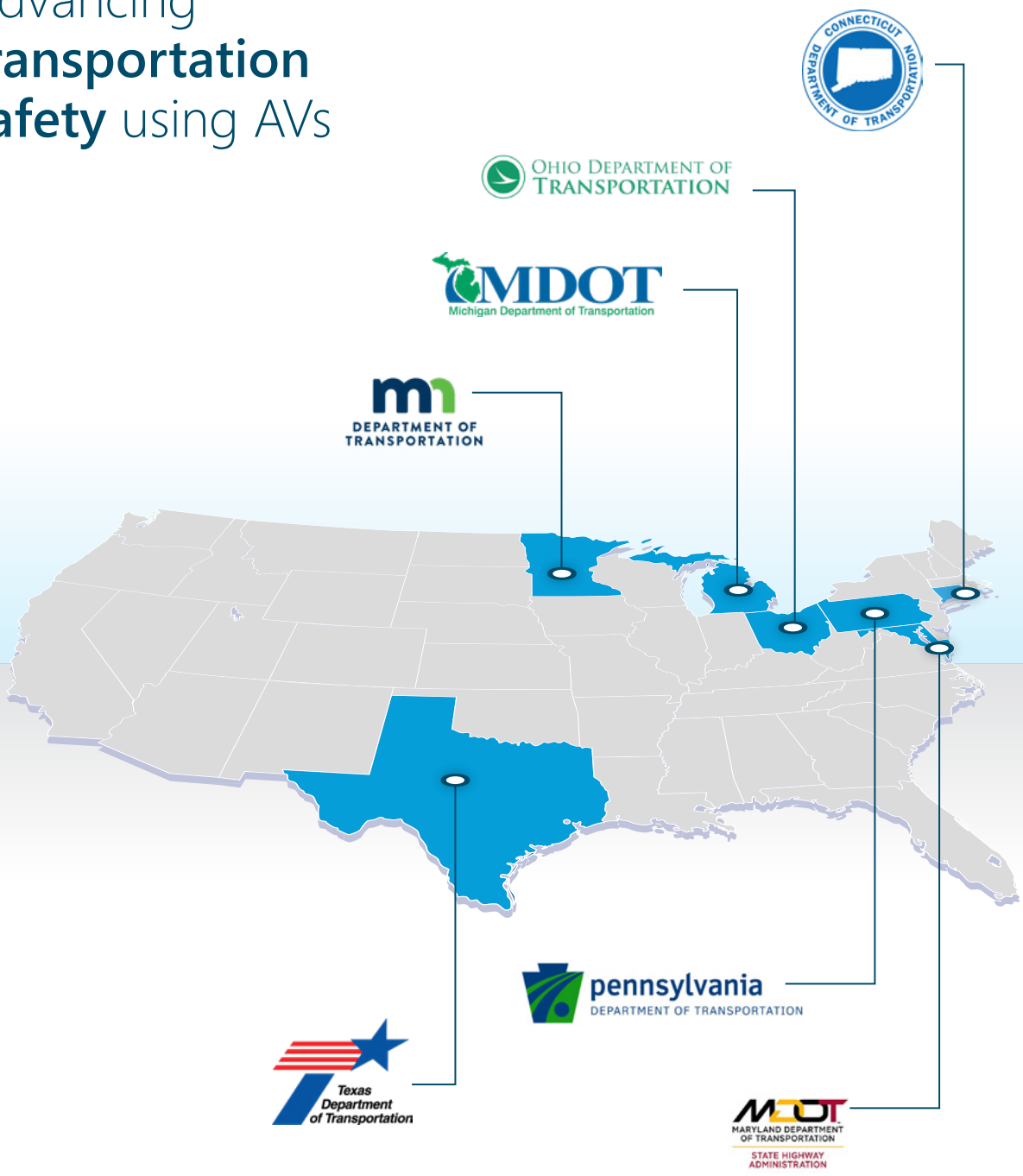
- **research** vehicle-roadway interaction, including data failures and mitigation methods;
- **identify** and define standards, and;
- **encourage** interoperability across state borders

The AV PFS is led by the Ohio Department of Transportation (ODOT). At the time of this study, members of the AV PFS include:

- Connecticut Department of Transportation
- Maryland Department of Transportation State Highway Administration
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ohio Department of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation

1 https://www.pooledfund.org/Details/Study/680

Advancing **transportation safety** using AVs



Introduction

Infrastructure owner operators (IOOs), including State Departments of Transportation, can support AV technologies by advancing, operating, and maintaining the physical and digital infrastructure for all roadway users, including AVs. While the promises of AV technology represent a significant opportunity for IOOs, long-term success will depend on IOO investments in the right strategies and initiatives. Over the past decade, a multitude of AV-focused special interest committees, groups and partnerships, across government, industry and academic sectors, have emerged to support AV testing and deployment. Many of these groups are engaging in meaningful efforts to generate work products that target specific needs, questions and challenges around AV deployment; however, these efforts are often developed ad-hoc without a clear vision of the broader implementation strategy within the nation.

Purpose of the Program Plan

The AV PFS commissioned the development of the ***IOO Strategic Roadmap for Accelerated Adoption of AVs*** project to consolidate guidance and identify Programs that support the ability for IOOs to nationally move forward towards integrating AVs into the surface transportation ecosystem. Currently, there is a lack of unified national guidance on effective and consistent AV programming. When implemented by IOOs across jurisdictions, these Programs may form the basis for a ***shared national AV vision that facilitates AV adoption and acceleration.***

PROGRAM PLAN VISION: Identify Programs that support IOOs to integrate AVs across jurisdictions into the surface transportation ecosystem.

The **OBJECTIVES** for this plan are to:

	Identify AV project challenges and cross-jurisdiction considerations
	Identify previous efforts and outcomes that can be advanced by the AV PFS
	Recommend Programs, or broad activities, that work towards achieving national, widespread AV adoption

The Program recommendations provided in this document support achievement of the project vision and objectives.

Contributing National AV Projects

There are several contributing national efforts to advance the deployment of AVs, led by IOOs, private sector, special interest groups and other coalitions. Future AV projects should leverage and build upon these efforts. A few of the key contributing national efforts are described below.

FHWA MUTCD Notice of Proposed Amendment (Line widths/contrast, sign orientation, LED refresh rate, work zones): The proposed amendments to the MUTCD reflect advances in traffic control device technology and will lay the groundwork for supporting ADS and the infrastructure of the future. The recommended update includes consideration of line width, sign orientation, Refresh/flicker rate for LED signs, signals, and "Ghost" lines in Work Zones.

Work Zone Data Initiative (WZDI): This initiative by FHWA is intended to develop a standard approach for collecting, organizing, and sharing data on the "when," "where," and "how" of work zone deployment. The goal of this national initiative is to create and accelerate the adoption of a consistent language for communicating work zone activity data across jurisdictional and organizational boundaries, leading to improved mobility and safety in and around work zones for both workers and the traveling public.

National Highway Automation Concept of Operations (ConOps): FHWA is developing a Concept of Operations (ConOps) to describe the integration and interaction of ADS with the roadway infrastructure and users. This ConOps will help IOOs identify actions needed to prepare for ADS integration related to organizations, physical assets and policy.

I-70 / I-75 Automation Crossroads of America: This project will provide freight companies and truck automation vendors an opportunity to deploy partially automated driving technology in daily "revenue service" operations on I-70 between Columbus and Indianapolis. Offering professional driver training for host fleets and performing an automation audit of I-70, the data collected will provide DOT partners the insights they need to ensure their roadways are ready for AVs.

Automated Vehicle Transparency and Engagement for Safe Testing (TEST) Initiative: AV TEST is a program initiated by NHTSA that provides an online, public-facing forum for sharing automated driving system on-road testing activities. The tool reveals on-road testing locations and data like vehicle types, uses, dates, frequency, vehicle counts, and routes. It shows information about state vehicle operation regulations, emergency response plans, and legislation, as well as links to the voluntary safety reports some vehicle operators publish.

Virtual Open Innovation Collaborative Environment for Safety (VOICES) Proof of Concept (PoC): VOICES Proof of Concept (PoC) will be a distributed virtual platform that will enable stakeholder virtual collaboration among participating entities (public sector including State and local governments, private sector, and academic institutions) in an intellectual property-protected virtual collaborative environment for research and interoperability testing of prototype CDA applications. As the first use case, the VOICES PoC will focus on CDA, research, and interoperability-distributed testing of Cooperative Automated Driving Systems applications as defined by SAE J3216: Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles.

Key Terminology Used in this Document

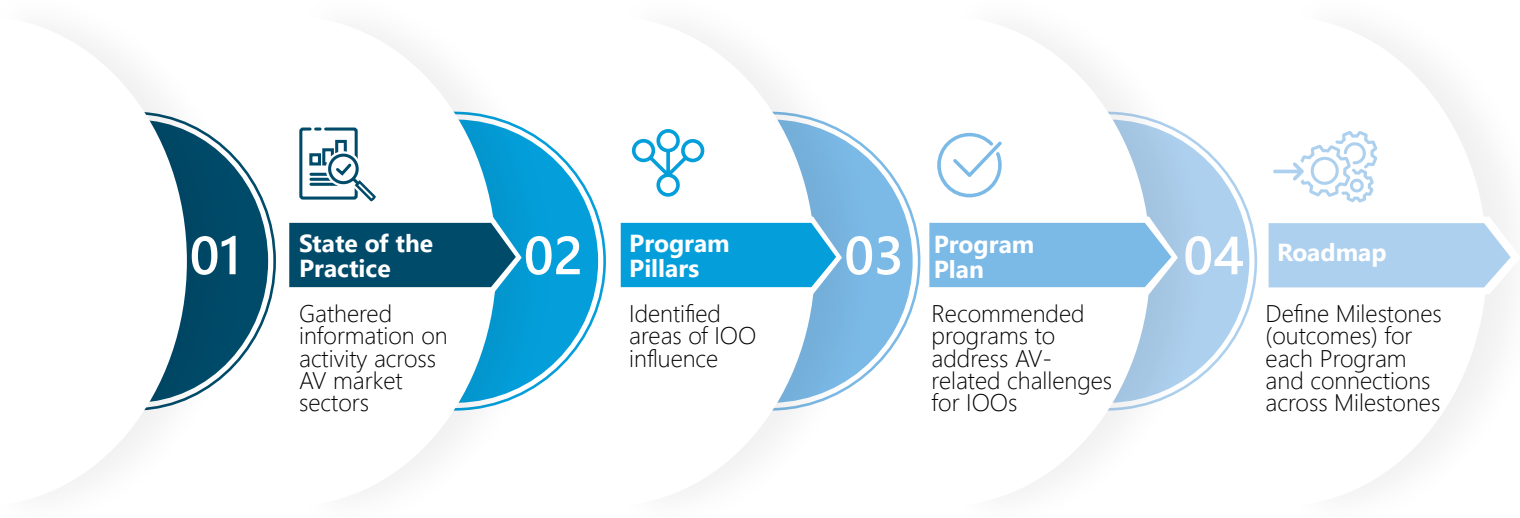
Term	Definition
Automated Driving Systems (ADS)	The hardware and software that are collectively capable of performing the entire Dynamic Driving Task on a sustained basis, regardless of whether it is limited to a specific operational design domain. This term is used specifically to describe a Level 3, 4, or 5 driving automation system. (SAE J3016)[2]
Automated Vehicle (AV)	Any vehicle equipped with driving automation technologies (as defined in SAE J3016).[2]
Electric Vehicle (EV)	A catch-all term for battery electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles.
Infrastructure Owner Operator (IOO)	An entity-- often a state or local public agency-- responsible for day-to-day operation and investment in infrastructure. IOOs are responsible for managing the roadways on which people, goods and services move.
Law Enforcement Interaction Protocols (LEIP)	Procedural guidance on law enforcement contact and interaction with AVs.
Control Device	A system that manages, directs, regulates and/or controls the behavior of another device or system.

2 https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf

Program Development

Development of the Program recommendations began with broad information gathering on AV industry capabilities; demonstration, pilot and deployment activity; and literature from industry, academia, and the public sector. Research was targeted at identifying IOO challenges and opportunities in facilitating AV activity. This information was used to develop a ***State of the Practice*** report.

The ***State of the Practice*** provides a summary of the prevalent AV market sectors: passenger, freight and transit, and market sector activity across testing, pilot and deployment stages. AV-related focus areas that can be influenced by IOOs were identified and serve as Program Pillars for targeting and organizing ***Program Plan.*** The recommended Programs herein provide broad activities that work towards achieving national, widespread AV adoption. The next step of this project will be development of a ***Roadmap*** that identifies Program Milestones and their interdependencies.



Program Recommendations

The Program recommendations identify tactical objectives that will help achieve the overall AV PFS vision, across seven Program Pillars related to areas of IOO influence:

Physical and Digital Infrastructure Readiness: The physical and digital environments that enable or enhance AVs

Workforce: Internal and/or external skill development support

Operations: Potential AV opportunities for day-to-day DOT functions

Communications and Engagement: Targeted outreach and communications

Interstate Freight and Multi-Modal Harmonization: Considerations for cross-state multi-modal AV travel

Policy: Regulations and standardization that support AV adoption

Partnerships: The pursuit of sustained partnerships

Program Recommendations

Pillar	#	Program	Description
Physical and Digital Infrastructure Readiness	1	Develop and apply control device requirements	Identify physical and digital roadway infrastructure requirement.
	2	Develop and implement AV data architecture framework	Develop an IOO/agency data architecture framework that provides a high-level understanding of how AV data will be put to use, with expected data flows, storage needs, etc. Align the architecture framework with the standards and language established by national data exchange initiatives.
	3	Utilize roadway readiness assessment	Coordinate federal, state and industry roadway readiness efforts to support the development of consistent metrics and evaluation methodologies.
Operations	4	Integrate AV technologies into traffic operations	Determine implementable use cases for AVs to serve traffic operations (e.g., traffic management and dispatch) to prove potential benefits of the technology to IOOs and travelers.
	5	Integrate AV technologies into maintenance and construction activities	Determine implementable use cases for AVs support maintenance and construction (e.g., automated crash attenuator vehicles, automated snowplows) to prove potential benefits of the technology to IOO workforce.
Interstate Freight and Multi-Modal Harmonization	6	Identify national AV freight corridors	Identify interstate corridors that are ready to support AV freight travel and communicate AV corridor locations to the industry.
	7	Support freight and multi-modal data exchange initiatives	Identify freight/multi-modal AV data sharing use cases to support continued improvement of existing data exchanges and the potential creation of additional data initiatives, as needed.
	8	Use AV technologies to support first/last mile connectivity	Identify first/last mile issues and potential AV solutions for freight (e.g., port operations) and multi-modal travel.
Partnerships	9	Facilitate sustained IOO-industry partnership	Sustain regular engagement of AV industry and IOOs to facilitate mutually beneficial information exchange and possible collaboration on work products.
	10	Engage in ongoing safety standardization efforts	Participate in efforts led by various standardization groups to inform the development of feasible safety standards for ADS-equipped vehicles that can be met in real world environments.
	11	Facilitate sustained partnership with public safety officials to share AV deployment information	Establish recommended communication process and reporting needs for industry and IOOs to share AV testing and deployment activity information with public safety officials.
Workforce	12	Prepare IOO organization and workforce for a transportation system that integrates AVs	Adopt flexible practices that support workforce adaptability and expansion, including robust workforce education programs to foster skills growth.
Communications and Engagement	13	Deploy and support public education efforts	Develop educational materials and mechanisms to address gaps in public knowledge and misconceptions that may lead to hesitancy or skepticism.
	14	Communicate with policy makers to provide input that informs legislation	Maintain two-way communication with policy makers to provide the latest AV information (e.g., innovations, issues, etc.) and review regulatory progress.
Policy	15	Participate in the development of common Law Enforcement Interaction Protocols (LEIPs)	Consolidate LEIP guidelines, across industry and associations, and identify best practice LEIPs to support common, widespread adoption and encourage the industry to respond to desired interaction needs.
	16	Facilitate compatibility between federal, state and local motor vehicle regulations	Participate in developing a framework that unifies best practices for AV licensing, registration, and insurance to support seamless transition of AVs between jurisdictions.

How to Read This Program Plan

The following details are provided for each recommended Program:

Program Pillar

Focus area addressed by each Program

Physical and Digital Infrastructure Readiness: | Operations | **Interstate Freight and Multi-Modal Harmonization** | **Partnerships** | **Workforce** | **Communications and Engagement** | **Policy**

Description

Describes the Program and an objective that will help achieve the overall AV PFS vision

Challenge

Identifies the challenge being addressed

Contributing Projects

Efforts that contribute to this Program and/or can be expanded by the AV PFS

Prioritization

Relative high, medium or low priority of each Program based on AV PFS member survey

PROGRAM PILLAR

Physical and Digital Infrastructure Readiness

PROGRAM 1

return to milestones

Develop and apply control device requirements

DESCRIPTION

Identify physical and digital roadway infrastructure requirements, related to pavement, structures, roadside equipment, communications etc., that support ADS. This includes identifying requirements that support typical use cases and roadway characteristics (i.e., signage and speed reduction for curves); identifying how AVs will be notified of, navigate and maneuver through work zones; identifying baseline connectivity needs; and any other requirements for ADS functionality in structured or unstructured environments. Additionally, minimum requirements for a roadway mapping schema must be identified.

PRIORITIZATION

CHALLENGES

- The AV industry has not clearly articulated infrastructure characteristics that facilitate and enhance ADS operation.
- The minimum physical footprint required for vehicle operation can vary by level of automation.
- Current ITS and communication standards may need to be modernized to consider the needs of ADS.
- Infrastructure requirements for traffic safety and safe integration of AV in Work Zones (i.e., vehicle pull off area) need development.
- Rural areas pose unique infrastructure challenges related to the use of farm equipment, presence of animals and vegetation, topography, extreme weather conditions, and lacking cell service and broadband access.
- Frequent maintenance activities may be required to maintain compliance with physical requirements.
- IOOs may need to partner with private sector or other organizations to provide AV-supportive infrastructure, such as EV charging. There is no guidance on establishing and maintaining these partnerships.
- Maps are often created and used by the AV industry, but there is no standard mapping approach that is common across IOOs and the industry.
- Navigation technology companies are publishing their own maps in proprietary formats.

CONTRIBUTING PROJECTS

FHWA MUTCD Notice of Proposed Amendment (Line widths/contrast, sign orientation, LED refresh rate, work zones): The proposed amendments to the MUTCD reflect advances in traffic control device technology, and will lay the groundwork for supporting ADS and the infrastructure of the future. The recommended update include consideration of line width, sign orientation, Refresh/flicker rate for LED signs, signals, and "Ghost" lines in Work Zones.

Mound Road Innovation Corridor: This corridor in Detroit, MI is implementing a unique digital infrastructure environment using the capabilities of the FHWA CARMA program.

Memorandum of Understanding between the Department of Energy and the Department of Transportation: This memorandum of understanding (MOU) was release in December 2021 to commit to establishing a joint Office of Energy and Transportation in the future that will support the deployment of EV charging infrastructure.

Open Mobility Foundation Mobility Data Specification (MDS): LADOT has developed the Mobility Data Specification (MDS), a data standard and API specification that allows the city to engage in real time with mobility service providers and digital infrastructure through a digital twin. The idea is for both cities and the private mobility companies—will operate off the same digital map, with MDS acting as the data and communication protocol.

PROGRAM 2

return to milestones

Develop and implement AV data architecture framework

DESCRIPTION

Support the development of an AV data architecture framework that leverages AV and IOO mechanisms for data sharing. Address data governance and management practices that facilitate data sharing with the private sector.

PRIORITIZATION

CHALLENGES

- Connected and automated vehicle data from pilots and deployments is often collected, stored and not actively utilized. Digital infrastructure needed to actively utilize this data has not been clearly articulated.
- Typical IOO data management practices may not support streaming and ingestion of private sector data. Both the AV industry and IOOs have data that must be protected (e.g., intellectual property, including trade secrets, personally identifiable information, and granular position data that would allow someone to identify or track a specific vehicle).
- Data governance across IOOs and AV industry are not consistent.
- IOOs and the AV industry often do not understand each other's terminology.
- As AV adoption increases, there is potential for extremely large amounts of data to be exchanged.
- The integration of AV data into existing IOO systems may be needed to actively utilize and maximize the potential benefits of that data.
- The industry and IOOs have not articulated priority use cases for shared data.

CONTRIBUTING PROJECTS

Automated Vehicle Transparency and Engagement for Safe Testing (TEST) Initiative: AV TEST is a program initiated by NHTSA that provides an online, public-facing forum for sharing automated driving system on-road testing activities. The tool reveals on-road testing locations and data like vehicle types, uses, dates, frequency, vehicle counts, and routes. It shows information about state vehicle operation regulations, emergency response plans, and legislation, as well as links to the voluntary safety reports some vehicle operators publish.

Smart Roadside Initiative: The Smart Roadside Initiative is a joint effort between the Federal Highway Administration (FHWA) and Federal Motor Carrier Safety Administration (FMCSA). The system, as envisioned, will facilitate the exchange of data among in-vehicle, roadside, and freight facility systems. This data will be shared, as authorized, with relevant parties to improve safety, efficiency and mobility, particularly in the freight sector.

Mound Road Innovation Corridor: This corridor in Detroit, MI is implementing a unique digital infrastructure environment using the capabilities of the FHWA CARMA program.

PROGRAM 3

return to milestones

Utilize roadway readiness assessment

DESCRIPTION

Coordinate federal, state and industry efforts to identify specific physical and digital environment characteristics that enhance the deployment of AVs, including any digital and physical infrastructure needs.

PRIORITIZATION

CHALLENGES

- Assessing roadway readiness must consider not only the built physical and digital environment, but also ADS capabilities relative to that operational design domain.
- 'Roadway characteristics that support or enhance AV deployment must be identified in partnership with both IOOs and the industry.

CONTRIBUTING PROJECTS

National Highway Automation Concept of Operations (ConOps): FHWA is developing a Concept of Operations (ConOps) to describe the integration and interaction of ADS with the roadway infrastructure and users. This ConOps will help IOOs identify actions needed to prepare for ADS integration related to organizations, physical assets and policy.

ETC Readiness Framework: This project explored the use of infrastructure readiness assessment methodologies in developing methods for assessing a multi-state region's readiness for automated vehicles. Completed in January 2021, the outcome of this project was a tested prototype assessment process tool that helps transportation infrastructure owners identify gaps and needs in their systems for preparation for AVs

I-70 / I-75 Automation Crossroads of America: This project will provide freight companies and truck automation vendors an opportunity to deploy partially automated driving technology in daily "revenue service" operations on I-70 between Columbus and Indianapolis. Offering professional driver training for host fleets and performing an automation audit of I-70, the data collected will provide DOT partners

PROGRAM 4

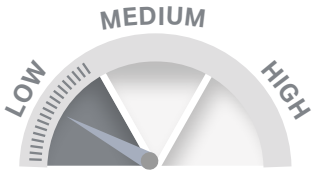
return to milestones

Integrate AV technologies into traffic operations

DESCRIPTION

Determine use cases for AVs to serve IOO operations that may be acted upon today (e.g., asset tracking, pothole detection, material transport). Addressing these use cases can prove the benefits of applying the technology to IOO activities.

PRIORITIZATION



CHALLENGES

- Industry development has not targeted IOOs as a consumer of the technology.
- IOO operations use cases are not well understood by the AV industry.
- Identifying impacts to existing IOO business practices and concepts of operation for each use case could require significant IOO stakeholder engagement.

CONTRIBUTING PROJECTS

Collaborative Sciences Center for Road Safety Concepts of Operations for AV Dispatch Operations: This report outlines the implications of AV proliferation on dispatchers, including public transportation dispatchers and State/regional operations management/dispatch. The study notes potential functions, including increased communication with AV fleets, that could have a positive effect on the timeliness of emergency response.

PROGRAM 5

return to milestones

Integrate AV technologies into maintenance and construction activities

DESCRIPTION

Determine use cases for AVs to support construction that may be acted upon today (e.g., automated crash attenuator vehicles, automated snow plows). Proving the efficiencies of AV technology in this area may be especially impactful, given the high cost of these activities for States and IOOs.

PRIORITIZATION

CHALLENGES

- AV technology for construction or maintenance vehicles is a very niche market, and not widely available.
- AVs in construction and/or maintenance environments must operate in close proximity to people in unstructured environments.

CONTRIBUTING PROJECTS

MNDOT Automated Truck Mounted Attenuator (ATMA) project: Currently, MNDOT uses truck mounted attenuators, also known as crash cushions, in work zones to protect roadside workers from the traveling public. To mitigate the risk of having a driver in the truck mounted attenuator, an ATMA could be used in work zones as the vehicle following a manned lead maintenance truck. For the project duration, a safety operator will be in the ATMA at all times, however the goal of this project is to study benefits of using ATMAs in the field to increase safety in work zones, and eventually use driverless ATMAs in workzones.

Autonomous Maintenance Technology (AMT) Pooled Fund: This Transportation Pooled Fund Study, has the objective of developing, demonstrating, and refining Autonomous Impact Protection Vehicles (AIPV) to prepare for widespread deployment for DOT operations. AIPVs are autonomous work zone vehicles positioned between work crews and the traveling public. AIPVs increases safety by removing the driver from a truck that is actually designed to be hit. This is an ongoing PFS with Colorado as the lead state.

CDOT SHIELD: Colorado DOT performed a study to research the effectiveness of integrating Autonomous Truck Mounted Attenuators into workzones. This study was conducted to observe real-world implications of ATMAs in the workforce. It was determined that automated technology in ATMAs would improve safety overall, however increased education of workers will be essential to increase worker comfort with ATMAs in the field.

PROGRAM PILLAR

Interstate Freight and Multi-Modal Harmonization

PROGRAM 6

return to milestones

Identify national AV freight corridors

DESCRIPTION

Collaborate with industry to identify criteria, including physical and digital infrastructure and regulations, that support AV freight travel. Based on those criteria, designate AV freight corridors across the nation. Develop a mechanism to track and expand the AV freight network.

PRIORITIZATION

CHALLENGES

- The industry is taking a lead in identifying AV freight-ready corridors, without IOO collaboration or clarity on the characteristics that are supportive of AV freight.
- AV regulations across adjacent states can vary, impeding seamless travel.
- A lack of consistency across deployment activities may result in infrastructure variations along freight routes.

CONTRIBUTING PROJECTS

I-70 / I-75 Automation Crossroads of America: This project will provide freight companies and truck automation vendors an opportunity to deploy partially automated driving technology in daily "revenue service" operations on I-70 between Columbus and Indianapolis. Offering professional driver training for host fleets and performing an automation audit of I-70, the data collected will provide DOT partners the insights they need to ensure their roadways are ready for partially automated vehicles.

Smart Roadside Initiative: The Smart Roadside Initiative is a joint effort between the Federal Highway Administration (FHWA) and Federal Motor Carrier Safety Administration (FMCSA). The system, as envisioned, will facilitate the exchange of data among in-vehicle, roadside, and freight facility systems. This data will be shared, as authorized, with relevant parties to improve safety, efficiency and mobility, particularly in the freight sector.

PROGRAM 7

return to milestones

Support freight and multi-modal data exchange initiatives

DESCRIPTION

Data exchanges play an enabling role in bringing AVs to market more quickly. Identifying use cases for national data exchange initiatives, such as the Work Zone Data Initiative (WZDI) and Smart Roadside Program, is fundamental to establishing data exchange needs and a common language to address those needs. IOOs should identify and routinely refresh use cases to support expansion and continued improvement of these vital data initiatives.

PRIORITIZATION

CHALLENGES

- Data exchanges have historically been built by defining needs and requirements up front. However, program needs are constantly evolving due to user requirements, technology advancement, and public acceptance changes.
- Data exchanges are often set up without feedback from end users.
- The large scope and number of stakeholders for national data exchanges can hinder timely and effective collaboration.

CONTRIBUTING PROJECTS

Virtual Open Innovation Collaborative Environment for Safety (VOICES) Proof of Concept (PoC): VOICES Proof of Concept (PoC) will be a distributed virtual platform that will enable stakeholder virtual collaboration among participating entities (public sector including State and local governments, private sector, and academic institutions) in an intellectual property-protected virtual collaborative environment for research and interoperability testing of prototype CDA applications. As the first use case, the VOICES PoC will focus on CDA, research, and interoperability-distributed testing of Cooperative Automated Driving Systems applications as defined by SAE J3216: Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles.

Data for Automated Vehicle Integration (DAVI) program: U.S. Department of Transportation (U.S. DOT) launched DAVI as a multi-modal initiative to identify, prioritize, monitor, and – where necessary – address data exchange needs for automated vehicles (AV) integration across the modes of transportation. The DAVI Guiding Principles define an approach for U.S. DOT and their stakeholders to prioritize and facilitate the iterative development of voluntary data exchanges.

PROGRAM 8

return to milestones

Use AV technologies to support first/last mile connectivity

DESCRIPTION

Identify specific first/last mile issues and potential AV solutions for freight (e.g., port operations) and multi-modal travel. Determine the feasibility of first/last mile solutions and plan for implementation.

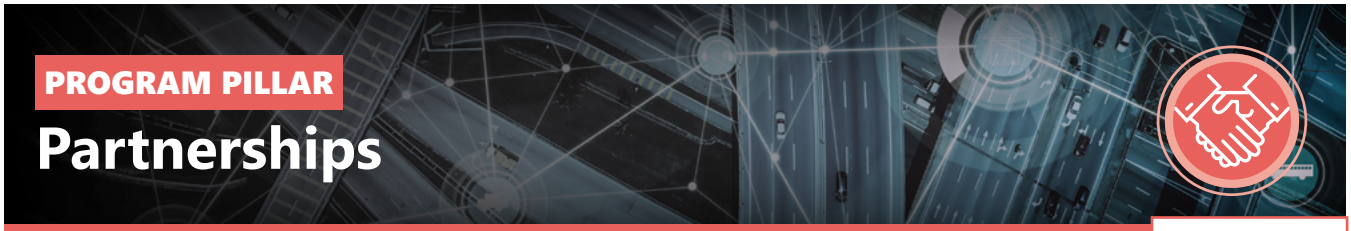
PRIORITIZATION

CHALLENGES

- First/last mile connections can pose unique, site-specific mobility challenges that are difficult to address at a wide scale.
- First/last mile travel often involves multiple stakeholders.

CONTRIBUTING PROJECTS

Data for Automated Vehicle Integration (DAVI) program: U.S. Department of Transportation (U.S. DOT) launched DAVI as a multi-modal initiative to identify, prioritize, monitor, and – where necessary – address data exchange needs for automated vehicles (AV) integration across the modes of transportation. The DAVI Guiding Principles define an approach for U.S. DOT and their stakeholders to prioritize and facilitate the iterative development of voluntary data exchanges.



PROGRAM 9

return to milestones

Facilitate sustained IOO-industry partnership

DESCRIPTION

Sustain regular engagement of AV industry and IOOs to facilitate mutually beneficial information exchange and possible collaboration on work products.

PRIORITIZATION

CHALLENGES

- Many communication efforts between IOOs and AV industry have been ad hoc to date.
- There is no clear, consolidated understanding of the AV interest groups that exist across IOOs and industry, their participants, work efforts and how these groups interact in the national AV context.
- Duplicative communication efforts may disincentivize participation.
- Sustained, long-term communication efforts face difficulties with maintaining excitement, continued participation, recruitment and appropriate follow up.

CONTRIBUTING PROJECTS

Partners for Automated Vehicle Education (PAVE) campaign: PAVE is a diverse coalition that helps enhance public understanding of driverless technology through: An educational website and social media channels; "Hands-on" demonstrations that allow the public to see and experience driverless technology; Other outreach events, such as conferences and public forums, that provide opportunities to engage with the public about AV technology and its potential benefits; and Policymaker workshops designed to provide real facts about AV technology to help policymakers make informed decisions

Autonomous Vehicle Industry Association (AVIA): The Autonomous Vehicle Industry Association advocate for the safe and timely deployment of autonomous driving technology. The association works towards ensuring safe and trusted AVs increase road safety, boost supply chains and improve mobility opportunities for all.

AV PFS IOO-Industry forum: The goal of this effort is to develop a long-term, collaborative and more active partnership with industry for the purpose of providing AV technology input to the AV Pooled Fund, as well as other prospective national and regional AV government-industry partnerships.

PROGRAM 10

return to milestones

Engage in ongoing safety standardization efforts

DESCRIPTION

Participate in efforts led by various standardization groups to inform the development of feasible safety standards that can be met by AVs operating on public roadways. Facilitate connections across safety standardization groups that are working towards the same goal.

PRIORITIZATION

CHALLENGES

- Multiple organizations are working to develop AV safety standards.
- AV safety standards must balance human level safety and zero tolerance.
- SAE International develops automotive safety standards, while the National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) develops traffic controller safety standards. These standards are not currently compatible.

CONTRIBUTING PROJECTS

Virtual Open Innovation Collaborative Environment for Safety (VOICES) Proof of Concept (PoC): VOICES Proof of Concept (PoC) will be a distributed virtual platform that will enable stakeholder virtual collaboration among participating entities (public sector including State and local governments, private sector, and academic institutions) in an intellectual property-protected virtual collaborative environment for research and interoperability testing of prototype CDA applications. As the first use case, the VOICES PoC will focus on CDA, research, and interoperability-distributed testing of Cooperative Automated Driving Systems applications as defined by SAE J3216: Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles.

UL 4600 Standard for Safety for the Evaluation of Autonomous Products: UL 4600 addresses safety principles and processes for evaluating fully autonomous products requiring no human driver supervision.

Automated Vehicle Safety Consortium (AVSC): The AVSC is an industry program of SAE Industry Technologies Consortia (SAE ITC) building on principles that will inform and help lead to industry-wide standards for advancing automated driving systems. The AVSC's efforts focus on the safer deployment of AVs. It's intended to be broadly applicable to all developers, manufacturers, and integrators of autonomous technologies for use in product deployment.

AAMVA guidelines: American Association of Motor Vehicle Administrators (AAMVA) developed jurisdictional guidelines for the safe testing and deployment of Highly Automated Vehicles (HAVs) that addresses 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. These guidelines are voluntary recommendations for jurisdictions that choose to regulate testing and deployment of HAVs.

Governors Highway Safety Association (GHSA): The GHSA has hosted panels to discuss traffic safety education and law enforcement during the deployment of AVs. The reports from these panels detail challenges regarding AV Policy and AV interaction with the public, as well as law enforcement, to ensure driver and public safety. GHSA has also been an advocate that safety must remain a priority as AV deployment continues, and has been working to urge the federal government to work with states to craft AV policy.

PROGRAM 11

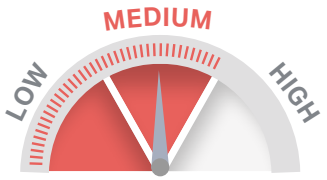
return to milestones

Facilitate sustained partnership with public safety officials to share AV deployment information

DESCRIPTION

Provide a recommended process and reporting needs for industry and IOOs to share AV testing and deployment activity information with public safety officials. Provide the latest available protocols on AV interaction with safety vehicles.

PRIORITIZATION



CHALLENGES

- Public safety officials are often overlooked as a partner in AV deployments, leaving them out of the loop on AV deployment projects.
- Law enforcement interaction protocols are not yet standardized, which raises questions and concerns from the enforcement community.

CONTRIBUTING PROJECTS

AAMVA guidelines: American Association of Motor Vehicle Administrators (AAMVA) developed jurisdictional guidelines for the safe testing and deployment of Highly Automated Vehicles (HAVs) that addresses 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. These guidelines are voluntary recommendations for jurisdictions that choose to regulate testing and deployment of HAVs.

PROGRAM PILLAR

Workforce

PROGRAM 12

return to milestones

Prepare IOO organization and workforce for a transportation system that integrates AVs

DESCRIPTION

Anticipate and prepare for the acceleration of AV technology, which will change mobility and transportation network needs. Make incremental steps towards adopting agile and scalable business practices that support the ability to respond to change. Implement workforce education programs to foster adaptability and skills growth.

PRIORITIZATION

CHALLENGES

- Future impacts of AV technology on transportation infrastructure, management and maintenance needs will likely be significant, though they are still unclear. Traditional IOO organizational structures are not agile or able to quickly adapt to change.
- The IOO workforce may need to evolve to accommodate new and modified roles.
- Uncertainties around the adoption of emerging technologies can cause reluctance to make supportive investments to expand the workforce.
- Many IOOs do not currently have the resources to support organizational changes related to AV adoption.
- Workforce resistance to AV technology is often driven by the misunderstanding that there will be no human role required.

CONTRIBUTING PROJECTS

Regional Express Access Lanes (REAL) Plan: The REAL Plan by TxDOT proposes an agile transportation system connected through mobility hubs that will mitigate some of the Houston region's most pressing mobility problems and be adaptable to future growth and innovation. The plan present a long-term vision for the future that shows how the transportation network will evolve over time to move people and goods.

ITS Professional Capacity Building Program: The Intelligent Transportation Systems Professional Capacity Building (ITS PCB) Program is a mechanism for educating the transportation workforce about ITS. The program has provided the transportation workforce with flexible, accessible ITS learning and support through live and on demand training, technical assistance, and educational resources. In addition, the program focuses on community building where coalitions, centers, cohorts, and awareness/education/training on automation and emerging technologies will play a significant role in ITS deployment.

PROGRAM PILLAR

Communications and Engagement

PROGRAM 13

return to milestones

Deploy and support public education efforts

DESCRIPTION

Develop educational programs for general users of AV technologies including curriculum and educational venues for these courses to take place.

PRIORITIZATION

CHALLENGES

- There is public hesitancy, skepticism and a lack of understanding of AV technologies.
- AV terminology is not consistent, which can lead to confusion and misunderstanding.
- Relatively few incidents involving level 4/5 AVs have made significant impacts to public trust in the technology.
- There is no unified, trusted source for AV information catered towards the general public.
- Questions from the non-workforce public often go unanswered.
- The potential economic impacts and benefits of EVs and AVs have not been clearly communicated.

CONTRIBUTING PROJECTS

Partners for Automated Vehicle Education (PAVE) campaign: PAVE is a diverse coalition that helps enhance public understanding of driverless technology through: An educational website and social media channels; "Hands-on" demonstrations that allow the public to see and experience driverless technology; Other outreach events, such as conferences and public forums, that provide opportunities to engage with the public about AV technology and its potential benefits; and Policymaker workshops designed to provide real facts about AV technology to help policymakers make informed decisions.

PROGRAM 14

return to milestones

Communicate with policy makers to provide input that informs legislation

DESCRIPTION

Maintain routine communication with policy makers to exchange information on regulatory progress and the latest AV innovations.

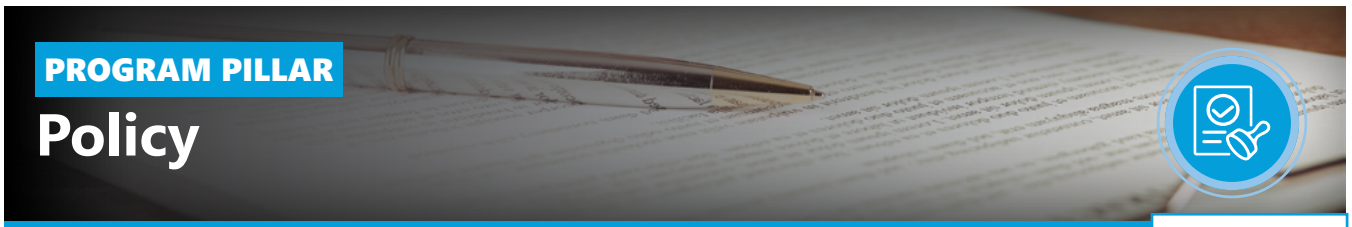
PRIORITIZATION

CHALLENGES

- AV policy often lags behind the technology, which can hinder deployment.
- Policies can inadvertently favor one business model over another, eliminating technology-neutrality.

CONTRIBUTING PROJECTS

Partners for Automated Vehicle Education (PAVE) campaign: PAVE is a diverse coalition that helps enhance public understanding of driverless technology through: An educational website and social media channels; "Hands-on" demonstrations that allow the public to see and experience driverless technology; Other outreach events, such as conferences and public forums, that provide opportunities to engage with the public about AV technology and its potential benefits; and Policymaker workshops designed to provide real facts about AV technology to help policymakers make informed decisions.



PROGRAM 15

return to milestones

Participate in the development of common Law Enforcement Interaction Protocols (LEIPs)

DESCRIPTION

Confirm existing guidelines for LEIPs (see AAMVA guidelines). Adopt common LEIPs across jurisdictional boundaries to encourage industry to respond to desired interaction needs.

PRIORITIZATION

CHALLENGES

- Many states and jurisdictions have not established clear protocols for public safety vehicle interaction with AVs.
- Motor vehicle regulatory agencies need guidance on AV interaction policies and protocols.
- AV technology lacks some of the capabilities required to detect public safety vehicles and behave appropriately.
- There is no standard AV identifier for public safety officials.

CONTRIBUTING PROJECTS

Model State Policy: The model state policy, developed by NHTSA in concert with the American Association of Motor Vehicle Administrators and private-sector organizations, suggests state roles and procedures, including administrative issues (designating a lead state agency for autonomous vehicle testing), an application process for manufacturers that want to test vehicles on state roads, coordination with local law enforcement agencies, changes to vehicle registration and titling, and regulation of motor vehicle liability and insurance.

AAMVA guidelines: American Association of Motor Vehicle Administrators (AAMVA) developed jurisdictional guidelines for the safe testing and deployment of Highly Automated Vehicles (HAVs) that addresses 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. These guidelines are voluntary recommendations for jurisdictions that choose to regulate testing and deployment of HAVs.

PROGRAM 16

return to milestones

Facilitate compatibility between federal, state and local motor vehicle regulations

DESCRIPTION

Participate in developing a framework that unifies best practices for AV licensing, registration and insurance to support seamless transition of AVs between jurisdictions. While all of these regulations are not primary IOO responsibilities, they can highlight IOO support needs.

PRIORITIZATION

CHALLENGES

- AV standards and regulations vary across jurisdictions without coordination, which can hinder seamless AV travel.
- There is no structure for regularly occurring communication and collaboration on AV activities and standardization across jurisdictional borders.

CONTRIBUTING PROJECTS

AAMVA guidelines: American Association of Motor Vehicle Administrators (AAMVA) developed jurisdictional guidelines for the safe testing and deployment of Highly Automated Vehicles (HAVs) that addresses 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. These guidelines are voluntary recommendations for jurisdictions that choose to regulate testing and deployment of HAVs.

Next Steps

Programs to Action

These Program Recommendations identify numerous initiatives that the IOOs should undertake to integrate AVs into the nation's surface transportation system. While the Program Plan focus on high-level priorities, the Roadmap will provide stepwise milestones and interdependencies across Programs.

AUTOMATED VEHICLE
POOLED
FUND
STUDY