

Roadmap for Multimodal and Accessible Travel Standardization Work

Multimodal and Accessible Travel Standards Assessment

www.its.dot.gov/index.htm

Final Report – February 16, 2021
FHWA-JPO-21-845



U.S. Department of Transportation

Produced by DTFH6116D00052L
U.S. Department of Transportation
Intelligent Transportation Systems Joint Program Office (ITS JPO)

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Technical Report Documentation Page

1. Report No. FHWA-JPO-21-845		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Roadmap for Multimodal and Accessible Traveler (MAT) Standardization Work				5. Report Date February 16, 2021	
				6. Performing Organization Code	
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9. Performing Organization Name and Address ICF 1725 I St., NW Washington, DC 20006				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. DTFH6116D00052 Task 693JJ318F000363 / Travel Standards Assessment	
12. Sponsoring Agency Name and Address U.S. Department of Transportation 1200 New Jersey Avenue, SE Washington, DC 20590				13. Type of Report and Period Covered	
				14. Sponsoring Agency Code	
15. Supplementary Notes Robert Sheehan (TOCOR), Harry Crump (COR), Robert Brown (CO)					
16. Abstract The Roadmap for Multimodal and Accessible Traveler (MAT) Standardization Work ("Roadmap") is a set of recommendations of initiatives and actions that the USDOT may undertake to address gaps and trends in standards development to ensure inclusivity and equity to meet needs of all transportation users, including people with disabilities. The Roadmap presents the methods used to collect and assess needs and priorities, describes the criteria for selecting and justifying initiatives and actions, and the timeline for their implementation. Roadmap initiatives include not only standards development activities for information and technology layers, but also institutional activities, programmatic coordination, training and guidance, and research needs that promote a comprehensive standards development to deployment path for the USDOT.					
17. Keywords Multimodal travel, Accessible travel, ITS Standards			18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, VA, 22161		
19. Security Classif. (of this report) None		20. Security Classif. (of this page) None		21. No. of Pages 68	22. Price NA

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Executive Summary

Multimodal, on-demand, and accessible transportation technologies have seen significant advancements in the past decade. The development of standards for these technologies must be accelerated in order to support these modes and ensure that all travelers' needs are addressed to ensure that everyone is included and has equal opportunities to take advantage of these new technologies. Development of these standards within the standards framework described by this document fills gaps in the deployment and interoperability of multimodal and accessible travel systems envisioned by the USDOT's "Complete Trip" and "Complete Streets" concepts. For the development of these standards to be successful and meet the needs of the end users, application developers and consumers must communicate and coordinate efforts in a sustained manner.

The *Roadmap for Multimodal and Accessible Traveler (MAT) Standardization Work* ("MAT Standards Strategy" or "Strategy") proposes a strategy that supports standards development by identifying actions that help developers and consumers achieve fully accessible travel across modes and trip segments. These actions address gaps that were identified in the standards areas of mobility platform APIs, wayfinding and navigation, safety, integrated payment, curb access and management, and data representation of the public right of way. The criteria used to select actions included an assessment of the need, the opportunity for wide deployment, existing efforts and advocacy by standards development organizations (SDOs) and advocacy organizations that might be related, existing legal protections for vulnerable road users, including civil rights policies and actions, and the environment for sustained support of the standard development over time.

USDOT ROLE

USDOT's role in implementing this strategy is to build and generate a standards framework that facilitates programs, development activities, training, and innovation. This framework not only promotes standard adoption and interoperability, but is also inclusive of all end-users, including vulnerable road users and people with disabilities. The strategy recommends:

- Specialized focus on mobility on demand standards that aligns with the traveler-centric focus of the USDOT Complete Trips concept.
- Harmonization of standards emerging and under development by diverse standards development groups that are open and consensus-based, in the United States and internationally.
- Development of information standards and taxonomies that incorporate end-users and their needs, especially terms and values that accommodate universal design and accessibility for vulnerable road users.
- Development of tools, testing and guidance to encourage implementation and innovation particularly as part of USDOT grants and programs.

MAT STRATEGY -- INITIATIVES AND ACTION

The Strategy organizes detailed actions into five initiatives:

- Initiative 1: Institutional / Programmatic / Community Coordination
- Initiative 2: Information Layer
- Initiative 3: Technology and Infrastructure
- Initiative 4: Training and Guidance
- Initiative 5: Innovation and Research

Within Section 4, each initiative includes a number of actions and activities in order to achieve success for that action that are organized by time frame: short term refers to a time period of two years, mid term represents a two- to five-year duration, and long term would last longer than five years. The Strategy identifies stakeholders that would lead and participate in the standards development process.

Initiative 1: Institutional / Programmatic / Community Coordination addresses the need to establish strategies that promote standard coordination, adoption, and governance. The actions are described in Table 1.

Table 1: Initiative 1: Institutional / Programmatic / Community Coordination Actions

Action	Activities
1.1 Mobility Platform (MP) Coordination and Harmonization <i>Lead: Trade Association</i>	<ul style="list-style-type: none"> • Establish a MP consortium to coordinate standards efforts • Work with MP consortium to develop harmonization plan • Meet to continue harmonization effort and coordinate activities • Ongoing review of consortium purpose and lessons learned
1.2 Institutional Framework for Advocacy Participation in Standard Development <i>Lead: USDOT</i>	<ul style="list-style-type: none"> • Develop plan for advocacy participation framework • Target Advocacy Groups for relevant standard development • Implement and sustain actions from plan • Coordinate plan with Action 1.3 Program Strategy
1.3 Program Strategy for Deploying Standards <i>Lead: USDOT</i>	<ul style="list-style-type: none"> • Establish a MAT Center • Develop program plan • Implement program plan • Develop guidance related to MAT inclusive design • Add to the Resource Library (see Action 4.2 Resource Library)

Table 2: Initiative 2 Information Layer Actions addresses the need for systems to achieve interoperability through reference architectures, data taxonomies and ontologies, data dictionaries, reference data models or schema, use cases, message specifications, and message exchange and sequence diagrams. The actions are described in Table 2.

Table 2: Initiative 2 Information Layer Actions

Action	Activities
<p>2.1 Data Dictionary / Taxonomy and Harmonization</p> <p><i>Lead: Coordinated effort by Trade Associations</i></p>	<ul style="list-style-type: none"> • Review existing data dictionaries and extend if needed • Support initiatives to develop data dictionary and reference data models • Establish and support consortium of formal and informal standards groups to harmonize families of standards • Develop open source software collection and testing tools to verify conformance with standards • Continue harmonization efforts • Continue data dictionary efforts as needed; integrate new use case needs into data dictionary
<p>2.2 Use Case and Data Exchange Specifications</p> <p><i>Lead: ISO TC 204 WG 8 Public Transport and WG 19 Mobility Integration.</i></p>	<ul style="list-style-type: none"> • Identify, prioritize, monitor, and address standards needs • Support the development of MAT use cases and data exchange through micro-grants available through USDOT • Make improvements to the data exchange specifications
<p>Action 2.3 Extend Reference Architectures and Service Packages</p> <p><i>Lead: ITS JPO ARC-IT Team in coordination with Trade Associations and open (no-fee) consortium</i></p>	<ul style="list-style-type: none"> • Engage STA to develop PI reference architecture • ITS JPO ARC-IT: collect needs, gaps, use cases for VRUs. Implement process for developing new service packages. • PI: implement schedule for completion • PI: implement ref. architecture in commercial architecture tools • Review ARC-IT to include Service Packages needed to support PI Reference Architecture
<p>2.4 Develop Specifications for Public Right of Way (PROW) and Shared Use Paths and Conditions</p> <p><i>Lead: ISO TC 204 WG 19 together with the US Access Board</i></p>	<ul style="list-style-type: none"> • Extend/harmonize existing map data standards to include PROW / shared use paths, curb access with information on access • Develop performance specifications to collect mobility service provider and urban freight “last mile” delivery data • Develop performance condition index and testing protocols for sidewalk smoothness • Extend PROW Data models • Update Standards related to PROW / Shared Use Paths

Table 3 addresses need for uniform design principles for the construction and function of physical devices, tools, and facilities. The actions are described in Table 3.

Table 3: Initiative 3: Technology and Infrastructure Actions

Action	Activities
<p>3.1 Uniform Transit Sign Manual</p> <p><i>Lead: TRB and FTA</i></p>	<ul style="list-style-type: none"> • Initiate a TRB research effort for uniform transit signage • Develop uniform transit sign manual • Develop and adopt guidance for uniform transit signage • Establish microgrant program to deploy signs based on Manual • Develop testing and conformance guidelines
<p>3.2 Wayfinding and Navigation Sensors and Communications</p> <p><i>Lead: SDOs (e.g., IEEE)</i></p>	<ul style="list-style-type: none"> • Initiate a use case and requirements study • Develop standards for communications between local transponders and VRUs for indoor and outdoor wayfinding and navigation • Complete standard development for information, application, and presentation layers • Develop testing and conformance standards • Implement pilots to test standards • Develop guidelines and training for implementing standards • Develop open source software tools and APIs • Engage testing labs to certify compliance
<p>3.3 VRUs in the Connected to Everything Environment</p> <p><i>Lead: SAE and ISO TC 204 WG 19 (CV architecture and message standards) and SAE and ISO TC 204 TC WG 18 (communications standards)</i></p>	<ul style="list-style-type: none"> • Develop communication profiles and message sets between Connected Personal Safety Device (PSD) and CV on-board and roadside units • Develop standards for comprehensive profiles of VRU types • Deploy pilots to test inclusion of mobile devices • Update PSD standards to include wearables • Develop guidance on applying standards to mobile devices/ wearables • Develop standards for cooperative perception within SAE V2X Steering Committee to define and address needs of cooperative driving automation use cases • Update Standards related to Personal Safety Devices
<p>3.4 Automated Wheelchair Securement</p> <p><i>Lead: Co-leadership by automotive and assistive technology SDOs</i></p>	<ul style="list-style-type: none"> • Research best approaches for standards in this area • Collaboration between automotive and assistive technology SDOs • Develop testing and compliance standards • Develop implementation guides

Table 4 addresses the need for education and training of practitioners to adopt and use new standards. The actions are described in Table 4.

Table 4: Initiative 4: Training and Guidance Actions

Action	Activities
<p>4.1 Training and Guidance on Standards Implementation</p> <p><i>Lead: USDOT, coordinated with trade and industry efforts</i></p>	<ul style="list-style-type: none"> • Identify potential training about MAT standards • Initiate USDOT ITS Professional Capacity Building curriculum • Develop guidance on using CAV Standards for VRUs • Develop guidance on using CAV standards for MMVs • Develop selected MAT standards training modules and guidance • Develop guide for implementing indoor navigation technology • Update existing and/or develop new MAT standards training modules • Update existing and/or develop new MAT standards guidance
<p>4.2 Develop a Resource Library for MAT Standards</p> <p><i>Lead: USDOT, coordinated with trade and industry efforts</i></p>	<ul style="list-style-type: none"> • Implement a knowledge body (library) with MAT standards and create an online platform • Establish a knowledge body (library) for CV standards for VRUs Implementation • Develop a playbook for implementing standards • Develop lessons learned from initial deployments • Provide technical support for deploying standards to public agencies

Table 5 addresses the importance of USDOT to continue pursuing innovation and research to support MAT Complete Trips. USDOT should lead this effort with the support of grantee agencies and University Transportation Centers. Activities include identifying areas where research is necessary to develop standards for Complete Trips, such as curb and sidewalk access congestion management and traveler behavior prediction using mobile devices, wearables, or haptic sensors, and maintaining and sustaining a database of research and innovation projects and standards efforts.

Action	Activities
<p>5.1 Innovation and Research</p> <p><i>Lead: USDOT</i></p>	<ul style="list-style-type: none"> • Develop a plan for mapping research to standards • Identify areas where more research is necessary • Develop plan for research to feed standards efforts

Chapter 1. Introduction

Scope

The *Roadmap for Multimodal and Accessible Traveler (MAT) Standardization Work* (“MAT Standards Strategy” or “Strategy”) is a strategic plan for the United States Department of Transportation (USDOT) to address gaps and trends in standards development to ensure inclusivity and equity to meet needs of all end-users, including vulnerable road users and people with disabilities. This document presents the methodology for collecting and assessing needs and priorities, describes the criteria for selecting and justifying initiatives and actions, and describes the timeline for implementation. The initiatives include not only standards development activities for information and technology layers, but also institutional activities, programmatic coordination, training and guidance, and research needs.

Project Description

As Mobility on Demand (MOD) is increasingly implemented by transit agencies across the country, it is clear that the development and use of standards will greatly benefit future system deployments, particularly in terms of data sharing, mobility product and service development, and deployment. In developing standards, it is critical that they be identified based on the needs of all travelers, including persons with disabilities, older adults, and other underserved populations. Thereby ensuring high-quality, interoperable, relevant, and lower cost, seamless mobility services for everyone. The USDOT’s Accessible Transportation Technologies Research Initiative (ATTRI), which is integrally tied to MOD, focuses on these travelers. Through its efforts, ATTRI determined the importance of standards across four foundational considerations – Standard Accessibility Data Platform, Universal Design Standards, Integrated Payment, and Leveraging Existing Technologies¹.

Standardization is essential to facilitate interoperability among systems and advance adoption of new technologies. In recent years, a spectrum of multimodal, on-demand and accessible technologies have been introduced to travelers, however actual standards to support these technologies remain limited. Furthermore, these standardization activities are often taking place in silos, both in terms of geography and industry. To achieve the USDOT’s vision for accessible, equitable, seamless, and complete trips for all travelers, there is a need for collaboration and harmonization in standardization across industries representing various facets of the travel chain, whether they are segments of the trip or integration of trip segments (i.e., trip planning and payment integration). These concepts are clearly described in two

¹ See ATTRI Factsheet -- https://www.its.dot.gov/factsheets/jpo_attri.htm

USDOT initiatives to support all travelers. The first, *Complete Trips*, identifies all possible stages of a traveler's journey, including key transitions (for example, boarding a vehicle, paying a fare) and major points of mobility access. The second initiative addresses infrastructure / paths of travel domains. The infrastructure and paths of travel are categorized by the concept of *Complete Streets*. This concept was initially a USDOT initiative and later augmented by uniform design principles, performance and policy elements promoted by the National Association of City Transportation Officials (NACTO) and Smart Growth America, which defines Complete Streets as those “designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities.” This project addresses how to represent the dimensions, conditions, and status of the public right of way (PROW) into information standards for the traveler.

What is a Standards Roadmap?

A standards roadmap is a collection of strategies and respective actions that promote longer term goals. In the case of this MAT Standards Roadmap, the strategies provide a checklist of actions leading to the development of standards and institutional structures that meet the needs for fully accessible travel across modes and trip segments. In the case of this project, the Roadmap provides a list of standard activities that address gaps in existing and emerging standards to ensure *Complete Trips* and *Complete Streets* for multimodal and accessible travel. Lessons learned from early ITS standards activities in the US, open source specifications, and European Committee for Standardization (CEN) standards reveal the importance of three factors:

- Communities of application/data producers and consumers must actively participate and be invested in the development and implementation of the standard;
- Protocols and tools for collecting, testing, and disseminating information related to the standard work must be available; and
- Collaboration environments must be present and sustained over the standard life.

These factors have proven effective by many popular transportation standards. A USDOT MAT Standards Strategy must consider these issues from various viewpoints – Community Participation, Role of Public Sector, Interoperability in a Diverse Ecosystem, and Focus on Accessibility.

DIVERSE AND INVESTED COMMUNITY PARTICIPATION

Having a diverse, open, and engaged community participating in the development of the specification generates interest and participation in developing standards, tools, and continued improvements that meet the needs of the users and providers of the technology or infrastructure designed. For example, the General Transit Feed Specification (GTFS) took at least three years to mature and over six years to gain widespread use because the industry was not fully engaged in the process until a grassroots group evolved from the effort. On the other hand, the General Bikeshare Feed Specification (GBFS) went from infancy to widespread use in less than two years because it was developed by an association of engaged operators and vendors under the North American Bike Share Association (NABSA). Further, one could postulate that without the Google Transit map product, GTFS would not have the transit data provider (or vendor) support to drive adoption, whereas, NABSA which is composed of bikeshare organizations who are both providers and application developers, had a ready-made community, technical expertise, testing tools, sample code, and applications to generate and post their open data feeds.

The Strategy should ensure that the standards organizations that develop the standards are committed not only to engage the appropriate communities, but also provide support tools, guidelines, and reference implementations to deploy and sustain the standards.

ROLE OF THE PUBLIC SECTOR

There are several models for government-sponsored standard development programs that result in industry collaboration and deployment. For example, the approach taken to validate and deploy CEN standards is an example of an effective method to deploy complex information standards. The EU funds demonstration projects that revolve around the deployment of a standard such as the Network Timetable Exchange (NeTEx). Today, most European public transport and multimodal applications use NeTEx data to feed their multimodal systems with static and dynamic data. Demonstration of the NeTEx standard at more than one location and stakeholder involvement provided rich lessons learned, tools and templates for deployment. Reference models and guidance are published along with the European standard, and these are updated to meet evolving needs as mobility paradigms change. Similarly, USDOT's Intelligent Transportation Systems Joint Program Office (ITS JPO) is currently sponsoring the specification development activities, providing technical assistance, and micro-grants for deploying the Work Zone Data Exchange (WZDx), which is intended to enable infrastructure owners and operators to make harmonized work zone data available for third party use and improve safety on public roads.

The institutional, programmatic, and collaborative frameworks such as those adopted by CEN for NeTEx and USDOT for WZDx promote standard deployment and sustainability. To that end, they should include institutional and programmatic structures that drive priorities and actions.

INTEROPERABILITY IN A DIVERSE ECOSYSTEM

In addition, a standard must work in combination with other standards. Earlier phases of research conducted for this project discussed the need for standards to work together, whether vertically (through different layers of technologies and protocols) or horizontally (across multiple similar semantic and syntactic representations) as described in the Updated Standard Survey (see Project Research Approach below for description). When standards are developed independently through different organizations, inconsistencies, ambiguities, and incomplete requirements prevent interoperability. This necessitates collaboration and harmonization of the technical standards among the varied organizations developing standards for the various communities and domains. Several methods have been used to “harmonize” disparate technologies. Some are strongly coupled, meaning the standard is built on the technical approach used by other standards, some use the same language or concepts but encode and group information differently, and others build adapters or gateways to convert the technology from one model to another.

Collaboration among standards activities is essential to ensure an interoperable ecosystem that supports the multimodal and integrated transportation network. The Strategy will need to include venues for collaboration among diverse set of standards activities in the US and internationally to generate interoperative standard “stacks,” or profiles.

FOCUS ON ACCESSIBILITY

Many standards are developed to be technology and policy agnostic so they can be applied to multiple systems and users. Typically, information annexes apply the standard through an architecture instance or

user focused use case to reflect specific stakeholders (or actors). These annexes serve two purposes – first, to show for which actors the standard applies, and second, to validate the approach used by the standard to address the actor’s needs. However, most existing standards do not include accessibility or multimodal “travelers” in these annexes. For example, mobile safety devices and wearables are not explicitly identified. So, although many of the international Cooperative Intelligent Transportation Systems (C-ITS) and SAE Connected Vehicle (CV) standards claim to cover MAT topics, limited information is included to show how. From observation, vulnerable road users are typically not represented in these annexes and to that end, the standard may not be appropriately applied. The Strategy recognizes that standards exist that do not explicitly represent all types of travelers, however, the recommendations advocate the need for including MAT focused use cases and architecture instances in order to validate that the needs and requirements meet all traveler needs.

Project Research Approach

This Multimodal and Accessible Travel Standards Assessment (MATSA) project consisted of five tasks that inventoried and organized existing standards and standards efforts, identified gaps and opportunities for standards development, and engaged stakeholders. These tasks were as follows:

The Forward Looking Assessment [FLA] determined the types of standards to be considered and identified nine dimensions and characteristics of multimodal and accessible travel, six types of standards, nine potential impacts on standards development, and an analysis of gaps. The nine dimensions of multimodal and accessible travel include spatial, informational, accessibility, transactional, institutional, technological, modal, temporal, and equity dimensions. The six standards areas include path of travel, data sharing, exchange and privacy, integrated payment, wayfinding and navigation (WaN), automation and robotics, and human-machine interface standards.

The Survey of Standards and Emerging Standards White Paper [STD] inventoried existing standards related to multimodal and accessible travel and categorized different types of organizations developing these standards. The white paper was updated to incorporate additional existing and emerging standards and standards activities uncovered during the outreach effort. The additional SDO, information cards and inventory were recorded in the **Update Survey of Standards and Emerging Standards White Paper [STD-UP]**.

The Outreach Plan [OP] and Outreach Report [OR] described the activities and stakeholder engagement necessary to gather input from standards developers and end-user groups. The Outreach Plan and Outreach Report activities were organized by six key topic areas: Mobility Platform Application Programming Interface (API), WaN, Safety, Integrated Payment, Curb Access and Management, and Public Right of Way (PROW) and Indoor Navigation Data Representation.

The outreach effort consisted of conducting interviews, developing white papers, and presenting at meetings hosted by or including significant attendance of end-user and standard organization stakeholders. Key stakeholders were interviewed representing perspectives from over 30 disability organizations, advocacy groups, standard development organizations (SDOs), private companies, and government agencies. Additionally, three white papers were developed to supplement stakeholder outreach activities:

- Integrated Payment White Paper

- Mobility Platform API Comparison White Paper, and
- Uniform Transit Signage White Paper

The research team presented at the International Organization for Standardization (ISO) Technical Committee (TC) 204 WG 8 and 19, the ITSA MOD Alliance, the Mobility as a Service (MaaS) Alliance, the SAE On-Road Automated Driving (ORAD) Definitions Task Force, the Connected Vehicles to Everything (C2X) Task Force, and committee meetings.

The research team also developed an online questionnaire to supplement interviews and presentations; the questionnaire was organized by the six subject areas and respondents were asked to rate their level of knowledge of each subject area and answer questions pertaining to that subject area if they indicated a moderate level of knowledge or higher. For each subject area, qualified respondents were asked to list any existing or emerging standards that they were aware of, rank potential needs for standards development related to the subject area, indicate what roles different types of organizations should take in advancing standards and filling gaps, and mention any additional needs or considerations for that subject area. The questionnaire was distributed through identified stakeholder groups and was open from April 17, 2020 until May 12, 2020 and received 119 unique responses. Respondents' stated priorities for standards development activities and stakeholder involvement in standards activities are folded into the recommendations provided in the Strategy. These needs and priorities are summarized in the following chapter, while priorities pertaining to roles and responsibilities for each stakeholder group are described in Roles and Responsibilities

References

Citations for the above referenced documents are as follows:

- Schweiger, Carol, et al. "FHWA-JPO-18-744 Multimodal and Accessible Travel Standards Assessment – Forward Looking Assessment (FLA) White Paper". 6/21/2019.
- Chang, Annie, et al. "FHWA-JPO-19-774 Multimodal and Accessible Travel Standards Assessment – Survey of Standards and Emerging Standards White Paper". 10/29/2019.
- "Multimodal and Accessible Travel Standards Assessment – Outreach Plan". 12/19/2019
- Okunieff, Paula, et al. "FHWA-JPO-21-844 Multimodal and Accessible Travel Standards Assessment – Outreach Report". 8/12/2020 with the following White Papers:
 - Comparison of Existing Efforts to Standardize Mobility Platform APIs.
 - Integrated Payment.
 - Uniform Transit Signage.
- Chang, Annie, et al. "Multimodal and Accessible Travel Standards Assessment – Update Survey of Standards and Emerging Standards White Paper". 10/6/2020.

Document Organization

The MAT Standards Strategy includes six chapters and Appendices, as follows:

Chapter 1: Introduction. Chapter 1 provides the scope, background, and references associated with this Strategy.

Chapter 2: Identifying and Prioritizing Standards for the Roadmap. Chapter 2 summarizes the results of the outreach effort and recommendations from stakeholders on their priorities.

Chapter 3. High Level MAT Standards Strategy. Chapter 3 presents the high-level Roadmap through five sets of action lists (or initiatives): institutional/programmatic/community coordination, information layer, physical (technology) infrastructure, training/guidance, and innovation and research.

Chapter 4. Detailed Initiatives and Activities Description. Chapter 4 presents the benefit, justification, stakeholders, and a checklist organized by short, mid, and long-term actions for each action with the five initiatives.

Chapter 5. Roles and Responsibilities. Chapter 5 outlines the roles and responsibilities for stakeholder groups, including disability advocacy organizations, transportation organizations and associations, standard development organizations, and other stakeholders.

Chapter 6. Next Steps. Chapter 6 describes the next steps for advancing standardization through the actions outlined in the Strategy.

Appendix A. Acronyms.

Appendix B. Stakeholders.

Chapter 2. Identifying and Prioritizing Standards for the Roadmap

Input from stakeholders from the [OR], [FLA], and criteria for community inclusion and standard development organization policies establish the basis for identifying and prioritizing how to fill the gaps in standards for multimodal and accessible travel. This chapter summarizes the results of the outreach effort and recommendations from stakeholders on their priorities. The chapter also describes the criteria deemed most inclusive and consensus-based to ensure that all travelers, particularly in underserved communities, are represented and that standard developer organizations build open, needs-based, inclusive standards and specifications that will be deployed and sustained by commercial and public sector entities.

Identifying Standards for the Strategy

In the [FLA], a framework was developed to determine which standards would be considered, consisting of the following MAT dimensions:

- **Spatial**, which identifies the physical location of a traveler at each stage of a complete trip along with the infrastructure associated with each location (e.g., sidewalk ramps, lack of elevator); the features associated with the location (e.g., points, lines, paths); and the land use associated with the locations;
- **Informational**, which identifies data and information needs, and potential communication/dissemination media at each trip stage and each stage of service provision;
- **Accessibility**, which can be infrastructure based (handled in the Spatial dimension), vehicle based, and person based (e.g., needs related to mobility aids, personal care attendants, abilities and opportunities of individuals);
- **Transactional**, which covers trip request, reservation and payment, and data exchange, sharing and privacy;
- **Institutional**, which identifies the organizations that provide transportation services and the relationships among the mobility service providers;
- **Technological**, which identifies the types of technology that facilitate MAT.
- **Modal**, which identifies the types of transportation services that comprise MAT;
- **Temporal**, which identifies variations in the availability of opportunities across the day, week or other time period; and
- **Equity**, which identifies characteristics such as economic disadvantages, digital poverty, and the urban and rural divide.

These dimensions are not mutually exclusive. Rather, each dimension overlaps with one or more of the other dimensions. Further, these dimensions cover the four most important principles of MAT identified in the literature: safety, equitable access, access for persons with disabilities, and accountability/data access.

Based on an assessment of MAT dimensions and the state of practice for MAT standards development along with input from a variety of key stakeholders, the following six MAT standard areas were selected for analysis of needs, gaps, and opportunities.

The four areas of MAT standards development initiatives related to Complete Trips include:

- Mobility Platform API
- Wayfinding and Navigation
- Safety
- Integrated Payment

The two areas of MAT standards development initiatives related to Complete Streets include:

- Curb Access and Management
- PROW and Indoor Navigation Data Representation

The needs identified in the Complete Trips and Complete Streets areas were documented in the Outreach Report in addition to the standards gaps and summarized in Table 5.

Table 5: MAT Standard Gap Assessment Summary (Source: Outreach Report)

Standards Area	Gaps
Mobility Platform API	<ul style="list-style-type: none"> • Static trip planning • Safe trip plans and real time travel information • Structures for rule exchange • Consent APIs • Address the growing overlaps in standards development activities
Wayfinding and Navigation	<ul style="list-style-type: none"> • Standards for wayfinding field technologies that communicate with personal technologies (i.e., wearables, mobile apps) • Standards that provide performance condition index for surface smoothness that supports people with mobility devices, bicycles, e-scooters, people pushing strollers, etc. • Standards for consistent signage for transit, ridesourcing pickup/drop off locations, and directions to key touch points
Safety	<ul style="list-style-type: none"> • Standards for passenger vehicle accessibility for automated vehicles (AV) include wheelchair securement, pedestrian detection “profiles” and haptic alert technologies • A holistic approach to standards development where expertise is pulled from various sectors, geographies, and SDOs • Inconsistent or missing vulnerable road user (VRU) type taxonomies (e.g., conveyances and devices in addition to person and animal categories) • VRU concept model that includes relationship and information flows among VRUs, VRU conveyances, and VRU devices • Missing Use Cases for VRU scenarios • PROW data models and travel condition measures for VRUs • Extend and develop messages and performance measures to support additional Use Cases

Standards Area	Gaps
Integrated Payment	<ul style="list-style-type: none"> • Standardizing agreements for payment system integration between related partners such as mobility providers and card network providers • Data concepts to describe: <ul style="list-style-type: none"> ○ Commercial rules (reconciliation and settlement timing, fees, data sharing agreements) ○ Pricing rules (fare, product, parking, and road pricing descriptions) ○ Service usage ○ Travel histories and reporting semantics for consistency • Traveler consent data exchanges including definitions of each state and business to business (B2B) actions to take regarding states: B2B exchanges and rights based on traveler consent requests
Curb Access and Management	<ul style="list-style-type: none"> • Data standards to describe characteristics of the curb and adjacent rights of way specific to physical accessibility and paths of travel • Dynamic / real-time aspect of curb and sidewalk conditions: real-time reporting of obstacles affecting access and continuity • Performance metrics that indicate the physical accessibility of the curb and sidewalk • Inclusion of goods movement particularly as it relates to curb and sidewalk usage, including both static and dynamic use of the curb and sidewalk • Harmonization of curb and mobility data standards to support, for example, visualization and real-time navigation of curbs and sidewalks • Standards that reflect data used for navigation and describe right-of-way. In order to create routing opportunities in a multimodal situation, these standards should be integrated
Public Right of Way Data Representation including elements of Indoor Navigation	<ul style="list-style-type: none"> • Limited set of standards and stakeholder buy-in for attribute, condition and status definitions, terms, and values • Description of asset features that provide C2X WaN functionality • Limited reference architecture for collecting data on PROW characteristics, status, and conditions • Missing data feed formats, verification/compliance methods, tools for collecting data • Knowledge gap on existing standards -- their use including data collection, curation, and distribution

Specific priority areas for action are shown in Table 6.

Table 6: MAT Standards Priorities for Action (from Outreach Report Questionnaire Results)

Standards Areas	Priorities from Most Important to Least Important
Mobility Platform API	<ol style="list-style-type: none"> 1. Information exchange to support discovery, planning, payment, en-route information/re-routing, and trip histories for fully accessible door-to-door multimodal journeys 2. Information exchange to allow customer to consent to share their personally identifiable information (PII) in an integrated, multi-organizational environment 3. Information exchange to find the right path based on traveler mode and

Standards Areas	Priorities from Most Important to Least Important
	<ul style="list-style-type: none"> 4. Information exchange to match mobility devices (e.g., wheelchairs) with accessible vehicles 5. Information exchange and formats for mobility providers to share rules such as services, fees/tariffs, and operations
Wayfinding and Navigation	<ul style="list-style-type: none"> 1. Information exchange standards for the delivery of dynamic information related to transit operations to transit user's personal electronic devices or electronic information displays on-site 2. Information standards for transit agency/provider signage, websites, and mobile applications for the display and delivery of essential information that may be needed to facilitate a seamless trip under any conditions 3. Information exchange standards to gather and report out obstacles on sidewalks, pedestrian crosswalks, and other paths of travel in real-time 4. Standards for indoor mapping on mobile wayfinding applications with specific guidelines on customization capabilities, compatibility with personal assistive technologies, accurate navigation assistance, and provided information including points of interest and accessible paths of travel 5. Standards that allow mobile application users to customize how content is displayed and provided so the information is digestible and meets their individual accessibility needs (e.g., screen reader compatibility, text style, color, alignment, size, magnification, etc.) 6. Standardized implementation guidelines for indoor wayfinding technologies that provide accurate navigation assistance to the user with minimal maintenance to the provider, including location of signage to ensure visibility for all users at all times 7. Employee training standards for transit agency frontline staff that prepares staff for assisting customers with disabilities including disability awareness and etiquette, assistance techniques, and internal accessible services, facilities, and amenities 8. Design and human-machine interface standards for haptic technologies that provide navigation assistance to users, specifically those with hearing and/or vision loss and cognitive disabilities
Safety	<ul style="list-style-type: none"> 1. Connected Vehicle Standards to advance safety for all users and in particular, VRUs 2. Automated Vehicle Standards to advance safety for all users and in particular vulnerable, road users 3. Shared Use and Micromobility Vehicle (MMV) Standards to advance safety for all users and in particular, vulnerable road/bike lane/sidewalk users 4. Detection, alerts, and haptic sensory information to VRUs of near collisions and avoidances 5. Detection by vehicles and infrastructure of different types of profiles for VRUs
Integrated Payment	<ul style="list-style-type: none"> 1. Reference architecture that describes the actors and scenarios (use cases) that can be used to build and associate interoperable payment systems 2. Information exchange standards that define rules for exchanging service product, pricing, calculation, and product and customer account data (including privacy and consent) 3. Information exchange standards for point of sale and proof of payment data that support seamless trip tariff and payment across transportation and mobility options

Standards Areas	Priorities from Most Important to Least Important
Curb Access and Management	<ol style="list-style-type: none"> 1. Standardized data formats to support collection, storage, and sharing of curb data and regulations to support a variety of stakeholder needs and use cases such as mapping tools, analytic models, and digital information exchanges that support third-party information exchange 2. Development of information exchange standards that help cities and regulators collect mobility service provider data and monitor and measure regulatory compliance and performance in real-time or near real-time while providing sufficient user privacy protections and spatial accuracy 3. Information regarding obstacles that would hinder active mobility along a sidewalk or other right-of-way attached to a curb, such as street furniture, electric poles, curb cuts and the presence of parked MMV 4. Information exchange standards to support sharing of parking related data including on-street parking, accessible parking, and topological relationship with other curb elements
Public Right of Way and Indoor Navigation Data Representation	<ol style="list-style-type: none"> 1. Measures of the quality, completeness, and connectivity of bicycle paths and pedestrian footways 2. Use of electronic sensors to automate and standardize collection of physical infrastructure data such as sidewalk surface conditions 3. Indoor and PROW mapping models for collecting, navigating, and rendering travel path information 4. Standards that identify the presence and operational status of indoor/outdoor conveyances such as moving walkways, elevators, and escalators

Criteria for Selecting Initiative and Activity Options

Several criteria were used to select options for the Strategy. The inclusion of impacted end-user stakeholders in MAT standard development and review processes were considered along with the extent to which these standards were suitable for wide deployment and the long-term sustainability of such deployments. Additionally, multiple criteria were considered with respect to the standards themselves. These included the justification for developing a standard, the standards' scope, the processes by which a standard is developed and maintained, and the propensity for the stakeholder community to adopt the standard. Together, these criteria inform the MAT standardization methods, actions, priorities, and dependencies discussed in this document. This section explores these sets of criteria that were used to select actions and stakeholders in the high level MAT standards strategy framework.

SCOPE – It was critical to first identify the critical standard gap and ensure that there was indeed a demand for the development of the standard in question. The initial sets of stakeholders determined the topical, geographical, and industry scope and boundaries of the standard. This proved useful when identifying the anticipated “value add” that the standard in question will bring. The [OR] including interviews, questionnaire, and presentations at stakeholder groups provided a priority list of stakeholder group responsibilities, ranking of standard needs, and other relevant information.

OPPORTUNITY FOR WIDE DEPLOYMENT – A key metric used to evaluate the possible success for standards was the degree of implementation. A set of initiatives and activities to implementation were identified at early stages of the standard development process. In addition to meeting the criteria regarding scope and development process, the question of willingness and likelihood of a critical mass of

stakeholders to adopt and implement the standard in a timely manner was assessed. The timeliness of standards is of high importance, which was evaluated by the maturity level of the technology or the topic of the standard in question.

MAT standard development activities benefit from accompanying release of testing procedures and tools to support validation, collection, and dissemination of data in the appropriate format. Additionally, if funded by public entities, standards applied to open source software and open data specifications help promote transparency, availability, and interoperability among the greatest number of end-users and applications. These were important considerations when evaluating the possible future of the standard initiatives and actions because a lack of such tools may hinder wider use and adoption of the MAT standard.

Usability of the MAT standard was another key consideration that impacted the scale of deployment. It is a delicate balance to strike, as overly complex or esoteric standard aspects may be burdensome or difficult for end-users, while overly simple standards may fail to account for some aspects of the multimodal and accessible trip chain or other end-user stakeholder needs. This is where the scope and extent of the standard becomes critically important. By developing the minimal viable product in tandem with an initiative/action that details the future course of development, the standard can be scaled and refined over time in line with anticipated technological developments and end-user needs in order to be appropriate for the greatest mass of end-users. Assessing the scope, necessary features, and future scalability also allows time for the development and adoption of third-party tools that employ the standard using minimal viable specifications. Identifying the potential for future development of the standard can likewise support extended and refined future iterations of the standard. These considerations were critical to selecting and defining initiatives and actions.

INCLUSION AND REVIEW BY IMPACTED STAKEHOLDER GROUPS – To ensure that standards meet the needs of end-users, MAT standard development activities benefit from inclusion of ongoing input from impacted stakeholder communities and transparency to the wider community. The process to collect input from concerned stakeholder organizations about the standard in question was considered to the degree of openness and meaningful effort that was undertaken to engage with these stakeholder groups in the standard development process. Without these steps, adoption of standards may be limited, or their use may be contentious. For example, failure to include the perspectives of certain industry or public interest groups in MAT standard development processes may lead to concerns surrounding exposure of sensitive business or personal information. Similarly, failure to include robust representation from public agencies may limit the ability of these agencies to provide data feeds for consumption by third-party application vendors. Likewise, lack of representation from impacted traveler communities such as VRUs and persons with disabilities may limit the resulting standard's usefulness to the traveling public as a whole and impact its credibility among the wider community of practice. In each case, resulting standards risk limited adoption and long-term sustainability.

At present, however, many MAT standard development efforts have been led by closed consortia that develop use cases based on the internal needs of limited industry and/or public sector participants. Such closed and proprietary efforts may offer certain efficiencies and funding advantages. An open and transparent process, as well as outcomes, was important for the standards in question in order to ensure that the public interest was properly represented in the MAT standard development process. For MAT standards that include a public interest, however, these groups can make meaningful efforts to include not just the needs and perspectives of funding entities but also representatives from all concerned end-user stakeholder groups.

INCORPORATING LEGAL PROTECTIONS AND COMPLIANCE – In addition to inclusivity, MAT standard development efforts should ensure that the non-discrimination and equity principles in federal civil rights legislation and directives are upheld. These include policies and actions such as Title VI of the Civil Rights Act of 1964 and Executive Order 12898, which together seek to ensure that the programs and activities of Federal funding recipients advance non-discrimination and avoid disproportionate shares of benefit and burdens among different demographic groups. Similarly, the Americans with Disabilities Act (ADA) prohibits discrimination based on disability status in areas such as transportation, public accommodations, communications, and access to state and local governments' programs and services. Forgoing these considerations may limit adoption of downstream standard applications by public agencies, so standards were assessed for their support of public agency compliance with federal civil rights legislation and nondiscrimination principles, as well as their support of measuring distributional equity and access. Such limitations may inhibit public-private partnerships, the achievement of complete trips, and the advancement of equity and nondiscrimination in transportation.

In addition to federal civil rights legislation, some states have instituted consumer privacy protections with important implications for travel standard developments. Such acts, including the California Consumer Privacy Act (CCPA), may limit potential to collect and share personal information including but not limited to location data. To ensure compliance with such legislation and to minimize legal risks among end-users of the standard, travel standard development processes incorporated these privacy considerations and support minimizing compliance risks for downstream users. Standards considered the role of federal and state agencies to ensure legal protections were upheld in the travel standards development process.

SUSTAINING STANDARD DEPLOYMENTS – There are several aspects to sustaining standard deployment over time. Standards can be developed in a variety of ways, but it was important to assess whether a critical mass of stakeholders exist in order to initiate and continue to support the development of the standards in question. Standards in question were compared to existing initiatives in order to determine if they were competing or conflicting with one another and to identify strategies to harmonize initiatives, industries, and geographies. In most cases, the determination of where to house and how to develop and maintain the standard were strongly related to the needs defined by the critical mass of initial stakeholders. Which organization would be the most appropriate to house the standard and its development, as well as what would be the most appropriate and effective approach (e.g., open-source, American National Standards Institute (ANSI)-certified, closed consortium) were necessary questions to consider. The development process has a significant impact on the timeline, transparency, sustainability, and path to implementation of the standards in question. In addition to extensibility, usability, and inclusivity of diverse user needs, a variety of other factors determined the long-term sustainability of standard deployments. These included factors such as funding, composition of the developer community, and the ability to accelerate the timeline for standardization beyond current industry norms. Notably, travel standard development efforts in the US are not uniformly funded. Without dedicated funding streams, these efforts are typically volunteer led or may include piecemeal financial support provided to individual contributors by their employers. Such funding structures create limited incentive for long-term participation among individual developers, so the long-term funding streams were evaluated.

In addition to the inclusion of end user stakeholder groups, standard development efforts considered appropriate representation from a variety of types of technical experts. These include developers, testers, and implementers who should work with end users and with one another to ensure that needs are sufficiently addressed, testing protocols are in place, and that the standard will be widely usable by the desired audiences. These steps require coordination across development and deployment phases including a plan for meeting short-, mid-, and long-term needs and objectives.

Moreover, training and guidelines on implementing the standards is another area that contributes to the interoperability and sustainability of standard deployments. Recommendations and reference implementations provide for consistent application of a standard or group of standards deployed in a regional and national setting. For example, for many years, application of GTFS differed from agency to agency, and was inconsistent or incompatible with end-user applications. Knowledge transfer programs such as the USDOT ITS Standards Professional Capacity Building program, reference implementations, guidance on implementing the standard, case study resources provide a library of resources for end-users, service providers and system developers to deploy sustainable, interoperable systems.

Finally, rethinking the pace of MAT standards development is important for the long-term sustainability of these efforts. The rise of smartphones and the growing presence of private mobility service providers have led to rapid changes in the mobility ecosystem during the last decade. The typical pace of travel standard development cannot keep up with the changes wrought by these changing technologies and business models and therefore risks irrelevancy by the time of deployment. Meeting this challenge requires rapidly planning and developing a core product that can later be extended by the developer and end-user communities. Deciding which features are necessary for a viable product and which can be added later influenced the timeline for developing such features and therefore became a vitally important part of early scoping steps, because reducing the development scope could ultimately accelerate the timeline.

Chapter 3. High Level MAT Standards Strategy

The MAT Standards Strategy builds on the [FLA] and [OR] and provides stepwise recommendations for how the USDOT may address gaps in existing and emerging travel standard efforts. The Strategy is intended to provide actionable recommendations that can be implemented over the next few years with encouragement and support by the USDOT for key stakeholders including standard development organizations, trade associations, advocacy groups, crowdsourcing, and private sector organizations. It includes two components:

- **Strategy Initiatives** – These are broad areas of focus that contain multiple complete trip/street categories and play a role in addressing the previously defined MAT standards criteria. These strategic initiatives are designated to foster coordination and collaboration among standards organizations, crowdsourcing consortium, trade organizations, advocacy groups and private sector partners, both in the US and internationally. The Strategy identifies five initiatives that include institutional programs, information and technology standards, deployment training and resources, and further innovation and research needs.
- **Priority Actions** – For each of the five initiatives, the Strategy identifies actionable steps or activities that are recommended for advancing the deployment of MAT standards. These actions are staged to generate momentum by identifying actions that provide the building-blocks to develop and deploy over the mid-term and long-term periods. The actions are designed to support safe, seamless, and accessible journeys from origin to destination, including transition and transfer segments.

The High-Level MAT Strategy is shown in Table 7.

Table 7: High Level MAT Initiatives and Actions.

Initiatives	Priority Actions
Initiative 1: Institutional, Programmatic, Community Coordination	1.1 Mobility Platform Coordination and Harmonization 1.2 Institutional Framework for Advocacy Participation in Standard Development 1.3 Program Strategy for Deploying Standards
Initiative 2: Information Layer	2.1 Data Dictionary/ Taxonomy and Harmonization 2.2 Use Case and Data Exchange Specification Development 2.3 Reference Architectures and Service Packages 2.4 Specifications for PROW/ Shared Use Paths and Condition
Initiative 3: Technology and (Physical) Infrastructure	3.1 Uniform Transit Sign Manual 3.2 Wayfinding and Navigation Sensors and Communication 3.3 VRUs in the Connected to Everything Environment 3.4 Automated Wheelchair Securement
Initiative 4: Training and Guidance	4.1 Training and Guidance on Standards Implementation 4.2 Resource Library for MAT Standards
Initiative 5: Innovation and Research	5.0 Develop a plan for mapping research to standards, and promote potential research and innovation projects

MAT Standards Strategy Framework

Strategy Categories

As show in Table 7, the Strategy is composed of five sets of action lists that correspond to each of the five Initiatives, all of which were informed by earlier research and engagement activities. The initiatives are described in further detail below while the following chapter (Chapter 4) explores each action and its corresponding timeframe (near-, mid-, or long-term).

INITIATIVE 1: INSTITUTIONAL / PROGRAMMATIC / COMMUNITY COORDINATION – Institutional, programmatic, and coordination activities focus on actions and action lists that establish a framework for organizing people and programs to develop, coordinate, and deploy standards-based systems that promote multimodal and accessible travel. The initiatives start with a tactical plan that are implemented throughout the other Strategy categories.

INITIATIVE 2: INFORMATION LAYER – The information layer corresponds to the [STD-UP] OSI model extension (p., 5), the information layer “describes data meaning, format, and fitness for use (re: use cases) and architecture” (p., 6) in addition to the interface specifications (e.g., APIs). The [STD-UP] describes these types as Reference Framework, Use Cases, and Requirements. The Specification Types include data, message, and service specifications. Information layer initiatives and actions address gaps

in information layer components that drive the requirements and describe the elements or exchange information between the actors in the traveler’s environment. These include reference architectures, use cases, data dictionaries, APIs and specifications, and the testing procedures to ensure compliance with the APIs.

INITIATIVE 3: TECHNOLOGY AND (PHYSICAL) INFRASTRUCTURE – The technology and physical infrastructure standards deal with communications standards in the lower tier OSI seven-layer model, and hardware specifications, testing and performance measures. These types of standards correspond to assets such as signs, sensors, equipment, and communications protocols that support collecting, channeling and provisioning traveler information in the physical environment, as well as safety components such as vehicle securements for wheelchairs.

INITIATIVE 4: TRAINING AND GUIDANCE – Training and guidance focus on actions to support the adoption and deployment of standards. Many standards address technology that supports travelers, but there is little in the way of training and guidance on how to apply those standards.

INITIATIVE 5: INNOVATION AND RESEARCH – Innovation and research needs provide a selected list of research that validates standard approaches or accelerates the deployment of standards by testing alternative methods.

Timeline

Each action within the Strategy includes multiple parts that depend on other actions and initiatives taken over several years. The timeline depends on the steps and procedures implemented by the SDOs such as draft, review and comment periods which differ from organization to organization. To accommodate the differences, the timeline is composed of relative timing categories – **short, mid, and long-term periods**.

- Short term represents an action that starts within the current year and has a maximum duration of about 2 years from initiation.
- Mid-term represents a two to five-year duration, and
- Long term is greater than five years.

In the standards world, a standard may take as long as two to three years to develop and approve.

Testing and deployment of the standard can take even longer. Given those conditions, it is imperative that innovation and research occur prior to or simultaneously with standard development activities for the standards to incorporate the leading technology edge.

Strategy Initiative Dependencies

There are many dependencies among the recommendations. A technical standard depends on the information layer faithfully representing the physical environment, that is, the data conveyed by a wayfinding device represents the physical world. Dependencies among standards is discussed in [STD-UP, Figure 2] in reference to the extended Open System Interconnection (OSI) model. The model describes layers that implement communication services that cooperate with other OSI layers. Each layer is implemented using a formal set of base standards. Standard development organizations standardize the sets as a “profile”. The International Organization for Standards (ISO) and International

Electrotechnical Commission (IEC) developed the ISO/IEC TR 10000-1 Information technology — Framework and taxonomy of International Standardized Profiles — Part 1: General principles and documentation framework (reviewed and confirmed in 2013). A profile is a set of one or more base standards or International Standard Profiles (ISPs) “*necessary to accomplish a particular function*”.² An ISP is “an internationally agreed-to, harmonized document which describes one or more profiles.”³ The consensus based, harmonization principles drive dependencies of the elements within groups of profiles. The technical report goes on to describe groups of profiles for interchange format and representative, application, transport, and relay. A *device profile* would include at least one profile for each of the profile categories, and an information profile that is part of the extended OSI model. An *information profile* would provide a harmonized set of specifications that include architecture, use cases, data and message sets.

The MAT Standards Strategy Framework groups the standards and related activities and their dependencies into groups that show the dependencies and harmonization efforts that will need to occur to ensure interoperability and interconnectivity. As shown in Figure 1, Initiative 2 focuses on information standards and generating consistent, harmonized information layer standards and specifications; Initiative 3 focuses on the plant (physical) specifications that incorporate ISPs for device level standards. The ISPs go beyond the standards that are developed in Initiative 2 to include industry based interchange format and representative, application, transport, and relay profiles developed in the larger Information, Communications and Technology (ICT) ecosystem, particularly those associated with connected and autonomous vehicles.

In addition, as mentioned in Criteria for Selecting Initiative and Activity Options, implementation guidance, consistent use and maintenance drive development and sustainment of standards and standard profiles. These drivers are described in Initiative 1 – Institutional and programmatic drivers, Initiative 4 – Training and guidance, and Initiative 5 – Innovation and Research. These initiatives frame the standard development activities included in Initiatives 2 and 3 shown in Figure 1. Figure 1 describes the Enhanced OSI Reference model is used as a framework to organize the MAT standard needs, and the frame around the MAT development activities show forces that drive policy, training and research initiatives.

² ISO/IEC TR 10000-1, definition of Profile, Section 3.1.4.

³ Ibid., definition of an ISP, Section 3.1.2.

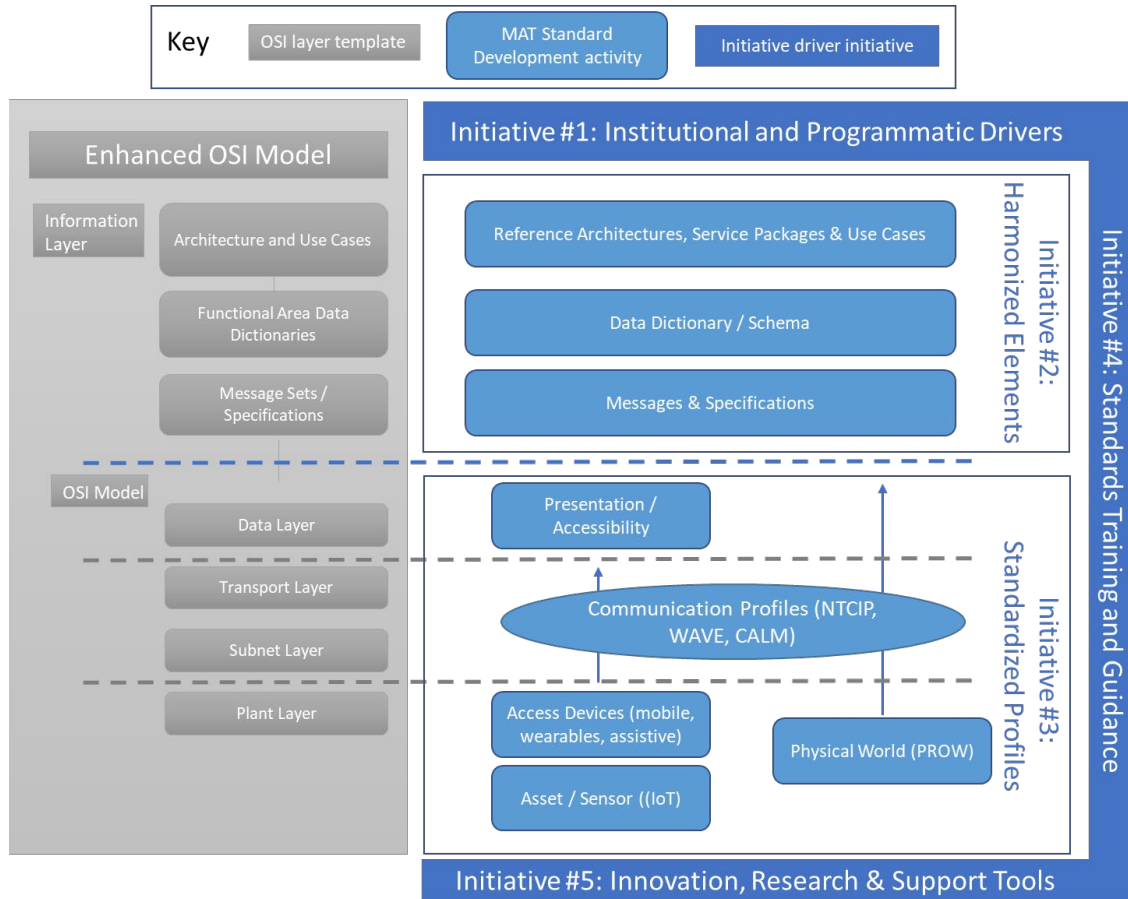


Figure 1: Strategy Initiative Dependencies and relationship to Enhanced OSI Model

The slow rollout of standards from development to deployment is a major obstacle addressing accessibility needs. Initiating programmatic support, innovating with technologies, developing data collection tools, and conducting training can help to accelerate deployment even if a standard is not yet approved or mature. For example, the CV Pilot program and USDOT ITS Standards Professional Capacity Building program is resulting in guidance, training, and lessons learned studies that support further deployment and adoption of best practices. A comprehensive program supported the CV effort, and the MAT community would benefit from a similar program.

Roles and Responsibilities

In conducting the outreach activities (documented in the Outreach Report), the questionnaire developed by the project team included a question for respondents to indicate what roles different types of organizations should take to advance standards and fill gaps in the four MAT areas identified related to Complete Trip and the two related to Complete Streets. The organization types included:

- Standards Development Organizations (e.g., SAE, ISO, IEEE)

- Trade Associations (e.g., APTA, Alliance for Automotive Innovation)
- Advocacy Groups (e.g., AARP, American Council of the Blind, Open Doors Org.)
- Private Sector Companies (e.g., tech and automotive companies)
- Crowdsourced development (e.g., open-source, GTFS) (also known as grassroots organizations)
- Research Organizations (e.g., TCRP, NCHRP)
- Government (e.g., USDOT)

The possible roles were for an organization to lead, participate in, or support activities that would advance standards and fill standards gaps. The organization types most identified by the respondents identified SDOs to lead complete trips areas, while government was voted highest for complete streets areas. Surprisingly, government was ranked a close second to lead complete trips standard development areas. The differences between government and SDO are shown in Table 8. Each column corresponds to the vote (percent and count) by role (Government or SDO), the difference between them (Delta), and the total number of respondents (Total Respondents) per MAT standard area. (Only individuals with a moderate level of knowledge or higher were asked to respond to the specific questions for each standard area.)

Table 8: Lead Role: Government vs. SDO

Standard Area	Government	SDO	Delta	Total Respondents
Mobility platform	58.00% 29	60.00% 30	-2.00% (1)	50
Wayfinding and Navigation	43.59% 17	61.54% 24	-17.95% (7)	39
Safety	66.67% 40	73.33% 44	-6.66% (4)	60
Payment integration	51.52% 17	57.58% 19	-6.06% (2)	33
Curb access and management	71.43% 25	58.82% 20	12.61% 5	35
Public right of way / indoor navigation data	63.16% 12	57.89% 11	5.27% 1	19

The results of the questionnaire regarding organizational roles in each of the standard areas are shown in Table 9. Even though the lead role was assigned to SDOs for the four complete trips areas, Government has a significant role in facilitating, promulgating and implementing the standards.

Table 9. Organizational Roles in Advancing Standards and Filling Standard Gaps.

Standard Area	Lead	Participate	Support
Mobility platform	Standards Development Organizations	<ul style="list-style-type: none"> • Advocacy Groups – local government • Private Sector Companies 	Crowdsourced
Wayfinding and Navigation	Standards Development Organizations	<ul style="list-style-type: none"> • Trade Associations • Advocacy Groups – disability organizations • Private Sector Companies • Crowdsourced • Research Organizations 	Crowdsourced
Safety	Standards Development Organizations	<ul style="list-style-type: none"> • Advocacy Groups – local government, transit 	Crowdsourced
Payment integration	Standards Development Organizations	<ul style="list-style-type: none"> • Private Sector Companies 	Crowdsourced
Curb access and management	Government	<ul style="list-style-type: none"> • Advocacy Groups – local government, local businesses, and economic development groups 	Crowdsourced
Public right of way / indoor navigation data	Government	<ul style="list-style-type: none"> • Trade Associations • Advocacy Groups – disability rights organizations 	Crowdsourced

Based on these questionnaire results, the past performance of these types of organizations in terms of standards activities and the recommended activities described in Chapter 4, the following roles and responsibilities are recommended to ensure that the MAT standards meet the needs of all travelers within the complete trip context, including persons with disabilities, and are sustainable in the long term.

Acting Standards/Specification Developers

Standards can be ideated, developed, and maintained within various types of organizations. This is especially true in the case of MAT standards where cross-sector collaboration is critical. In this Strategy, four types of host organizations have been identified along with their respective roles and responsibilities.

SDOs – The vast majority of existing standards in the automotive, communications, and assistive technology realms are hosted by traditional SDOs. The greatest advantages of developing standards at SDOs include the ability to leverage robust development procedures that ensure consensus building as

well as a relatively streamlined process to be adopted in regulation. This Strategy identifies the following responsibilities of SDOs:

- Coordinate with USDOT to identify priority MAT standards to develop
- Initiate the development of new MAT standards as well as revision of existing MAT standards
- Strengthen coordination with other SDOs and other standards communities to work towards harmonization while reducing duplication and silos

Consortia – Industry standards require a robust group of champions to not only develop standards, but also to implement and deploy them. Consortia may bring together a group of initial stakeholders with like-minded interests to develop standards in an accelerated manner. In some cases, consortia-born standards may be transitioned to traditional SDOs. Examples of consortia include the MaaS Alliance, which gathers public agencies and private mobility companies to develop MaaS API standards. This Strategy has identified the following as the responsibilities of consortia:

- Coalesce the initial critical mass of stakeholders to rapidly develop standards
- Demonstrate organizational buy-in through active participation in the consortia
- Forge consensus among competitors

Research Organizations – Sufficient levels of confidence in the technology and its approach are often required prior to developing standards. Whether independent or pooled, research may serve as the foundational knowledge feeding the content of the standard. Research organizations include academic institutions and groups such as University of Michigan Transportation Research Institute, which has conducted extensive studies on wheelchair tiedown and securement in vehicles. This Strategy has identified the following as the responsibilities of research organizations:

- Gather and analyze data to expand knowledge around technologies and/or test technologies
- Serve as the preliminary step to developing standards
- Conduct pilots to test validity of technological applications

Crowdsourcing / ad-hoc standards initiatives – More recently, crowdsourced, grassroots, and open-source development has gained popularity for code-based standards such as APIs. Open-source development often offers transparency in the standards development process coupled with broader engagement opportunities by various contributors. The crowdsourcing specification development responsibilities are similar to those of SDOs. Because they are composed of volunteers, there is more of a necessity to recruit, involve, and integrate advocacy and end-user stakeholder needs in their development efforts. For example, the WZDx effort included a charter to include the involvement of both data producers and consumers. To incorporate accessibility requirements, the various end-user accessibility groups may also need to be represented.

End-User Stakeholder Groups

The end-users of standards including application and equipment developers, general disability groups, and transportation agencies, are critical stakeholders in the standards development space. Yet involvement of these groups in travel standard development processes have generally been limited to the identification of travel standard needs and the deployment of these standards in downstream applications.

Findings from earlier outreach phases of the MAT standards assessment support an active and ongoing role for end-user stakeholder groups in MAT travel standard development processes. This Strategy has identified the following roles for end-user stakeholder groups in the development, deployment, and sustainment of MAT standards:

- Identification of use cases and participation in developing standards based on these use cases
- Crowdsourcing data collection (e.g., PROW conditions)
- Harmonization of needs and priorities across industry sectors and areas of practice (e.g., tolling and parking)
- Participation of legal experts and stakeholders including potential plaintiffs
- Cross-discipline engagement from research to standards
- Focus group development and participation
- Linking data collection to revenue streams (e.g., parking, commercial loading/unloading, etc.)
- Private sector coordination and leadership

In addition to those opportunities identified above, the research findings support an ongoing role for end-user stakeholder groups in identifying the gaps and weaknesses in existing MAT standard applications and reviewing the functionality of MAT standards as they are deployed.

USDOT

The role of USDOT describes responsibilities to initiate, promote, and fund an array of activities to enable, deploy, and build interoperable multimodal and accessible Complete Trips and Complete Streets.. In this role the USDOT facilitates initiation of standards that benefit end-users particularly public sector needs, inclusion of a diverse set of stakeholder participation in standard development activities and promotes standard adoption; responsibilities also include funding standard development, knowledge transfer, deployment guidance, and facilitating harmonization of standards from multiple standard organizations. Responsibilities are divided into these two roles as follows:

Responsibilities Related to **Promoting** Existing Standards and new Standard Development

- Promote MAT standards in Federal grant opportunities
- Promote the explicit inclusion of accessibility needs in standards by supporting advocacy group participation in standard development activities
- Support MAT standard adoption through programmatic efforts
- Promote standards harmonization from different standard organizations through joint technical working groups, pilots, and leveraging data collection and testing tools
- Create special focus of CV program on VRUs and their participation by the standard development organizations
- Promote open data APIs, specifications, and software efforts where discussion of the standard needs and development processes are transparent and open without fees.

Responsibilities Related to **Funding** the Development and Deployment of Standards

- Fund public sector personnel to participate in open source and open data specification development activities
- Fund microgrants for public sector standards implementation
- Fund microgrants for adoption of public sector data collection standards and implementation of

- data collection tools based on standard outputs
- Fund training and guidance that focus on VRU adoption of CV technologies
- Offer training on standards with a focus on deployment to support Complete Trips and Universal Design
- Provide free access to standard documents through funding standard development activities

Impacts of International Standards Development Activities

RECONCILING US AND INTERNATIONAL APPROACHES TO TRAVEL STANDARDS DEVELOPMENT

Travel standard developments in European and Asian countries tend to be more formal than in the US. For example, CEN provides dedicated funding streams and a framework through which EU member countries can contribute to standard developments and pilot the standard in projects. Resulting technical standards, such as NeTEX, feature not only the core capabilities of GTFS but a wider array of passenger information and operational applications such as curbside management, mobility as a service options, and features that support active transportation. By comparison, similar capabilities are being developed as standalone efforts in the US on an ad hoc basis.

These differing approaches to travel standard developments have also created differing definitions and use cases that lead to further divergence between US and international efforts. For example, although Norway and several US jurisdictions use the OpenTripPlanner, the Norwegian deployment applies NeTEX place information, which is much richer than GTFS and GTFS-pathways combined. Consequently, MAT standard stakeholders in the US are faced with choices such as the following: (a) embrace the more comprehensive and consolidated travel standards being developed abroad despite lacking a voice in these processes (b) continue to develop travel standards through a grassroots ad hoc process or (c) pursue an indeterminate hybrid approach.

Chapter 4. Detailed Initiatives and Activities Description

Initiative 1: Institutional / Programmatic / Community Coordination

Filling gaps in standards extends beyond merely developing the standard specifications and protocols. Adoption includes providing governance processes, promoting projects in a formal and comprehensive manner, and supporting and facilitating community participation in and coordination of development activities. There are many examples of these types of institutional and governance programs that have been implemented or facilitated by the USDOT and other international communities. The USDOT CARMA PlatformSM is a comprehensive program to develop consistent, comprehensive, standards-based, open source software tools and demonstrations that promote adoption and harmonization among a diverse set of standard organizations and industry consortium. The WZDx effort, an open effort to accelerate the development and adoption of the work zone data exchange specification combined with technology assistance and microgrants is another example of a strategy facilitated by the USDOT for grassroots development and deployment of standards. As noted in the [OR], many advocacy and industry groups as well as North American and international standards activities are working independently and overlapping in their efforts. To this end, the three actions presented in Initiative 1 address the need to establish strategies that promote standard coordination, adoption, and governance in the areas of Complete Trips and Complete Streets. The three actions include:

Action 1.1 Mobility Platform Coordination and Harmonization recommends coordination of Mobility Platform development of similar standards that ensures data and APIs are harmonized across domains and international efforts.

Action 1.2 Institutional Framework for Advocacy Participation in Standard Development recommends the development of a Federal strategy to engage and solicit input for standards activities from key advocacy groups including ones for people with disabilities particularly when Federal funds are used for standards development.

Action 1.3 Program Strategy for Deploying Standards recommends development of a national approach to include standards implementation for Federal grants.

Action 1.1 Mobility Platform (MP) Coordination and Harmonization

Benefits and Justification

Harmonization and coordination of mobility platform standards will enable universal, worldwide standards while spreading the development across countries to better use the limited resources available. The number of standards that are required to provide a complete trip in a complete street environment are

significant and complex, making coordination among these standards challenging. Some coordination efforts focus on one standard profile versus another, for example the EU has adopted Transmodel / NeTEx standards while North America unofficially uses the GTFS family of standards. A coordination effort will support consistency in developing and applying harmonized profiles while increase the international marketplace.

Stakeholders –

US-based Lead – Trade Association

US Participation –

- Data specification developers such as trade organizations, consortium and standard organizations.
- Advocacy Groups that represent end-user communities such as industry consortium, vendors, and consultants
- Government Organizations including US Access Board

Table 10. Action 1.1 -- Mobility Platform Coordination and Harmonization

Term	Action 1.1 Checklist
Short	<ul style="list-style-type: none"> • Establish and sustain a MP consortium of SDOs and consortiums to coordinate efforts for harmonization • Work with MP consortium to develop harmonization plan for mobility platform / mobility marketplace system including how to harmonize architecture, taxonomy, actors, use cases, APIs and methods (encoding, orchestration, etc.). Plan should include allocation of roles for development, testing and support tool efforts among Consortium members and charter for organization.
Mid	<ul style="list-style-type: none"> • Meet to continue harmonization effort and coordinate activities and deployment opportunities
Long	<ul style="list-style-type: none"> • Revisit charter and lessons learned from harmonization

Action 1.2 Institutional Framework for Advocacy Participation in Standard Development

Benefits and Justification

Many standards fill needs of end-users whether they be vendors, public agencies, vulnerable groups such as older adults, low income families, people with disabilities, or other VRUs (e.g., bikes, e-scooters, other MMV). Although most SDOs are consensus-based, without a membership fee, few have requirements for inclusion and diversity even though the standard topics they represent provide inclusive designs. The result is that there is little guidance on how to apply some of these standards, like integrating personal

safety devices into the Connected Vehicle CARMA Platform eco-system. For example, CV standards⁴ describe the architecture for docking mobile devices in vehicles but does not mention methods for docking personal (safety) devices (like mobile phones and wearables) with MMV or wheelchairs. The ISO⁵ implemented guidance on how every standard deployed should address the needs of “older persons and persons with disabilities.” The European Standardization Organization (CEN)⁶ implemented a checkbox in their new work item (PWI) to state the impact of the standard on accessibility. Because the public sector has a mission to ensure access to vulnerable groups, this action recommends that the USDOT establish an institutional framework to facilitate and promote inclusion of accessibility advocacy groups in the standard development processes. This institutional framework will encourage policies to include vulnerable road users when developing tools for managing curbs, addressing intersection management, and other shared-use facilities.

Stakeholders --

Lead – USDOT

Participate –

- USDOT Modal Administrations,
- US Access Board,
- Advocacy Groups representing vulnerable groups where relevant
- SDOs

⁴ ISO 24102 series on ITS-Stations, specifically ISO 24102-6:2018 Intelligent Transport Systems — Communications Access For Land Mobiles (CALM) — ITS Station Management — Part 6: Path and Flow Management.

⁵ ISO/TR 22411:2008: Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities

⁶ See <http://boss.cen.eu/formtemp/NewWI.docx> (see item #10)

Table 11. Action 1.2 Institutional Framework for Advocacy Participation

Term	Action 1.2 Checklist
Short	<ul style="list-style-type: none"> • Develop plan for advocacy participation framework in standards development that includes key performance indicators (KPI) <ul style="list-style-type: none"> ○ Pilot plan actions to measure KPI effectiveness. ○ Describe outreach and inclusion methods to include advocacy groups in USDOT funded standard development projects. • Target list of current standard activities and specifications that may require extensions or guidance to involve Advocacy Groups (several are identified in the [OR] and included in Appendix B)
Mid	<ul style="list-style-type: none"> • Implement and sustain actions from plan for advocacy participation • Coordinate plan with Program Strategy for Deploying Standards (Action 1.3)
Long	<ul style="list-style-type: none"> • Review and assess plan effectiveness

Action 1.3 Program Strategy for Deploying Standards

Benefit and Justification:

The results of prior project tasks show that there is a need to develop a comprehensive strategy for deploying harmonized standards, specifically those that address multimodal and accessible travel, despite the large number of stakeholders and identified standards gaps. Many current standards in this area focus on infrastructure rather than travelers, are not necessarily interoperable, and can be somewhat duplicative. Thus, a program strategy for deploying standards is needed to ensure that many of the gaps identified in the Outreach Report are addressed in a systematic way.

Almost all of the recommended actions to address gaps in MAT standards include the need to make standards consistent, to ensure that the appropriate stakeholders are asked to participate in standards development and deployment, and to encourage collaboration and coordination within and across MAT disciplines, as well as across SDOs and geographies. Establishing a program strategy for deploying standards and promoting adoption of these standards will allow these actions to begin to take place, and will serve to expedite the deployment. Further, one of the standard development criteria described earlier is related to standards implementation. Standards are only successful if they are deployed. Thus, a strategy for deploying standards is necessary in order to reflect proper standards development and testing, and to encourage adoption.

Two examples of program strategies that promote reference standard adoption were developed by USDOT and mentioned earlier in this report. The WZDx program was facilitated by the ITS JPO to support initial development of the WZDx specification. Joint leadership used to manage this effort is comprised of a diverse set of stakeholders including:

- Data producers, such as states, cities, and regions
- Data consumers, such as third-party data consumers like Waze
- Data hubs such as Regional Integrated Transportation Information System (RITIS) part of the University of Maryland

- Consultants

Microgrants were awarded by FHWA in January 2021 to support the preliminary development of complaint WZDx feed or expansion of existing feeds by infrastructure owners and operators to encourage adoption and technical assistance is free of charge.

The second example is the CARMA program, in which standards are implemented and information that drives the systems that provide the CV services is collected. The CARMA PlatformSM is an open source software (OSS)⁷ platform initiated by FHWA to enable the testing and evaluation of cooperative automation concepts to improve safety and increase infrastructure efficiency using CV standards (i.e., SAE J2735). The platform provides vehicles with the functions needed for automation and facilitates the development of new TSMO strategies while identifying TSMO scenarios that would benefit from cooperative driving automation.

Stakeholders --

Lead -- USDOT ITS Joint Program Office's (JPO's) ITS Standards Program

Participate

- US Access Board
- Federal Transit Administration (FTA)
- End-User / Advocacy Groups that represent end-user communities such as vulnerable travelers, industry consortium, vendors, and consultants

⁷ "The Open Source Software for Intelligent Transportation Systems (OSS4ITS) is an ecosystem that advances the deployment of interoperable transportation systems. The software suite provides infrastructure owner operators (IOOs), software companies, and device manufacturers a clear picture of the available open source software tools for both technical and business audiences. OSS4ITS stores the open source tools. Annual grants are issued to contribute to the industry guidance, and feed back into the standards process." (<https://usdot-oss4its.atlassian.net/wiki/spaces/OSSFITS/overview>)

Table 12. Action 1.3 - Program Strategy for Deploying Standards

Term	Action 1.3 Checklist
Short	<ul style="list-style-type: none"> Establish a MAT Center that provides knowledge and technical assistance in order to enhance collaborations to harmonize and advance MAT standards development and deployments without additional costs to standards users. Develop program plan to include MAT-related standards in related grant opportunities, including standards training, guidance and open source software for APIs, testing, and analysis
Mid	<ul style="list-style-type: none"> Implement program plan and request guidance and lessons learned reports from the MAT standards implementations Develop guidance related to MAT uniform design
Long	<ul style="list-style-type: none"> Add to the Resource Library (see Action 4.2)

Initiative 2: Information Layer

As described in the [STD-UP], the information layer covers the artifacts to ensure seamless interoperability between disparate systems. Interoperability covers unambiguous meaning, consistency, quality, completeness, and exchange of information. The types of standards and specifications include reference architectures, data taxonomies and ontologies, data dictionaries (meaning business rules, syntax), reference data models or schema, use cases, message specifications, message exchange and sequence diagrams, and more. These actions form the core of any data-driven system in that they provide the building blocks for describing available infrastructure, services, transactions, and performance for travelers. The actions described in this section compose the building blocks for deploying complete trips for travelers. The set of four actions are:

Action 2.1 Data Dictionary / Taxonomy and Harmonization recommends standards that describe unambiguous language, definitions, syntax, business rules, and reference data models upon which specifications and messages are built. These dictionaries and data models represent transportation network elements, assets, conditions, and status; services and mobility options; transactions; and performance measures.

Action 2.2 Use Case and Data Exchange Specifications uses the data elements, their meaning, and syntax to understand the context, content, requirements, and information flows between system entities in a scenario-based narrative.

Action 2.3 Extend Reference Architectures and Service Packages, using existing reference architectures including *Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)*, address gaps not currently included in logical or physical architecture models, or service packages. Reference architectures provide the framework for deployment including physical and functional objects and information flows.

Action 2.4 Develop Specifications for Public Right of Way and Shared Use Paths and Conditions to fill the gap of describing shared use paths such as pedestrian and bicycle and indoor paths through buildings. Though there are several models for indoor navigation, there are few for

sidewalks and fewer standards yet that measure the roughness acceptable for wheelchairs and MMV. This action, though overlapping with Action 3.1 (Uniform Transit Sign Manual) justifies its own checklist due to its importance in being the “glue” connecting modes in the Complete Trip.

Action 2.1 Data Dictionary / Taxonomy and Harmonization

Benefits and Justification:

Data-driven systems depend on clearly defined, unambiguous, uniquely named data elements to describe infrastructure and assets and relay information between systems. All the priorities identified in Table 6 that identify “data exchange” standards require a data dictionary of meanings and syntax to implement the messages to be exchanged. The action also includes the development of reference data models that describe the relationship between groups of data and how they are connected to form a data concept. Gaps in data taxonomies prevent consistent and complete vocabularies to uniquely describe terms. For example, there are several enumerations for wheelchairs in the standards reviewed. A single, authoritative source for the list of wheelchairs based on their physical features (footprint with/without a person, weight, power drive, folding dimension, etc.) would ensure that a consistent set of values are used across standards.

Many systems use more than one information taxonomy or data dictionary to build their vocabulary across modes, services, and asset types. The [STD-UP] report identified several standard profiles or families, although data element consistency only extends to the specifications within the family. When data element names and definitions vary between standards, harmonization is achieved either through developing data equivalency tables (matching synonyms) or by aligning concept names between standards. Given the global cooperation between the US and European Mobility Platform API development, this exercise of harmonizing data dictionaries will become even more critical. Even now differences in concepts are significant.

Stakeholders

Lead:

- For individual data dictionaries: Several depending on subject area (see Table 13 for lead designation)
- For Harmonization: Trade Association

Participants:

- All categories of stakeholders – SDOs, end-user groups, community organizations
- Harmonization Effort including: GTFS, CEN NeTEX, GBFS, MDS, Transport Operator to MaaS Provider API (TOMP-API), TCRP Report 210, and more.

Table 13. Action 2.1 Data dictionary / Taxonomy and Harmonization

Term	Action 2.1 Checklist
Short	<ul style="list-style-type: none"> • Support initiatives to develop data dictionary and reference data models for the following: <ul style="list-style-type: none"> ○ Vulnerable road user descriptions ○ Wheelchair and assistive device types based on dimensions, folding dimensions, weight, engine / power components (through the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)) ○ Parking (through the ISO TC 204 WG 19 effort) ○ Personally identifiable information (PII) levels and “opt-in” features and terms (similar to MyData.org) ○ Other data dictionaries as identified by the use cases • Establish and support consortium of formal and informal standards groups to harmonize families of standards; develop organization agreements re: harmonization approach
Mid	<ul style="list-style-type: none"> • Develop open source software collection and testing tools to verify conformance with standards • Continue harmonization efforts • Continue data dictionary efforts as needed; integrate new use case needs into data dictionary
Long	<ul style="list-style-type: none"> • Review existing data dictionaries and extend if needed

Action 2.2 Use Case and Data Exchange Specification Development

Benefit and Justification:

There are multiple benefits of use case and data exchange specification development. Generally, use cases are significant planning tools that facilitate iterative system development. Further, they reflect and describe desired system behavior expressed by stakeholders, and identify system functionality (“what” the system should do vs. “how” it should be done).⁸ Specifically, the Outreach Report made recommendations in the Mobility Platform API and Payment Integration areas that use cases be defined in order to ensure that standards developed separately are interoperable and that information flows of payment systems are documented (specifically in the areas identified in the Business to Traveler, and Business to Business processes), respectively.

⁸ http://www.itk.ilstu.edu/faculty/blim/itk353/NotesSlidesDocs/MKS_Use_Cases.pdf

In terms of data exchange specifications, generally, they “evolve in a fragmented and distributed fashion. To make integration and interoperability more efficient and scalable, the fragmented specifications need to fit into a coherent, semantic model. That is, they need to be logically consistent and contain minimal duplication.”⁹ Specifically, as described in the Outreach Report, the need for data exchange specification development in the Mobility Platform API area was recognized as a priority according to the results of outreach questionnaire and the identified standards gaps. As shown in Table 6, five types of data exchanges were identified as priorities. Further, data exchanges were identified as priorities in Wayfinding and Navigation, Integrated Payment, and Curb Access and Management.

Finally, this action meets all three Standard Development Criteria: Scope, Development, and Implementation. This action results from a definite and key standards gap; needs defined by a critical mass of initial stakeholders have been identified in this area; and it is likely that there will be adoption and implementation by a critical mass of stakeholders.

Stakeholders

Lead:

- ISO TC 204 WG 8 Public Transport and WG 19 Mobility Integration. Note: given that Europe has a set of robust public transport data exchange formats that better supports access and multimodal seamless services, the European Committee for Standardization (CEN) may be the appropriate SDO to lead this action, however, their standards are not consistent with the ones used in the US, for example GTFS or SAE J3194 on MMV, and data harmonization may be needed prior to developing the use cases.

Participation:

- US based:
 - End User Groups including Trade Associations and Transportation Organizations that represent all facets and developers of MAT standards
- International / European

⁹ Katherine C. Morris, Puja Goyal and Simon P. Frechette, “Development Life Cycle and Tools for Data Exchange Specification,” prepared for the National Institute of Standards and Technology, May 19, 2008, <https://www.nist.gov/publications/development-life-cycle-and-tools-data-exchange-specification>

Table 14. Action 2.2 Use Case and Data Exchange Specification Development

Term	Action 2.2 Checklist
Short	<ul style="list-style-type: none"> • Establish the MAT Initiative (similar to the Data for Automated Vehicle Integration [DAVI] Initiative), which is a multimodal initiative to identify, prioritize, monitor, and – where necessary – address standards needs for inclusive and accessible mobility across the modes of transportation. Each priority topic will have its own Working Group (similar to the Work Zone Data Working Group [WZDWG]) that will be responsible for overseeing the development of MAT use cases and data exchange specifications for that topic area.
Mid	<ul style="list-style-type: none"> • Support the development of MAT use cases and data exchange specifications in each of the six standard areas through micro-grants available through USDOT as part of a MAT initiative <ul style="list-style-type: none"> ○ Oversee development of use cases to address MAT standards gaps ○ Oversee development of new MAT use cases as needed ○ Oversee development of data exchange specifications to address MAT standards gaps ○ Oversee development of new data exchange specifications as needed
Long	<ul style="list-style-type: none"> • Make improvements to the data exchange specifications based on lessons learned from the initial MAT data exchange specifications and insights from the user/ stakeholder community

Action 2.3 Reference Architectures and Service Packages

Benefit and Justification:

Reference architectures provide a framework for system deployment, data exchange, stakeholder roles and responsibilities, component functions, and physical infrastructure. Two major areas were identified for this action: ARC-IT service packages to better support VRUs and Payment Integration (PI), as detailed in the [OR]’s Payment Integration White Paper.

In the ISO VRU gap analysis¹⁰, several use cases and service packages were identified as a gap to describe traveler accessibility and safety needs. Additionally, the PI white paper recommended the development of a reference architecture to serve as a framework by which different payment business models and vendor-licensed APIs could be mapped.

¹⁰ ISO WD 24317 Intelligent Transportation Systems— Mobility Integration – C-ITS for light mode conveyances and accessibility travel standards gap assessment

Stakeholders

Lead:

- For ARC-IT: USDOT ARC-IT Team
- For Payment Integration (PI): *Trade Associations that represent both financial, system, application developer, and advocacy groups (for underserved communities)*

Participate

- All categories of stakeholders – SDOs, end-user groups, community organizations

Table 15. Action 2.3 Extend Reference Architectures and Service Packages

Term	Action 2.3 Checklist
Short	<ul style="list-style-type: none"> • PI Ref. Architecture: Engage SCT to develop PI reference architecture; develop and send out call for participants, and develop document outline and schedule; begin development • USDOT: ARC-IT – collect needs, gaps, use cases for VRUs. Implement process for developing new service packages.
Mid	<ul style="list-style-type: none"> • PI: implement schedule for completion • PI: implement ref. architecture in COTS architecture tools for payment vendors to define their models
Long	<ul style="list-style-type: none"> • Review ARC-IT to include Service Packages needed to support PI Reference Architecture

Action 2.4 Specifications for PROW / Shared Use Paths and Conditions

Benefits and Justification

Generation of navigable complete trips relies on the unambiguous description and representation of all pathways on maps, whether they are a particular class of bike lane, sidewalk, curb element, building/station entrance or exit, or conveyance between floors (e.g., elevator, escalator, stairs). At present, the centerline representation of navigable maps does not adequately represent paths people (versus vehicles) use, the topological relationships of these paths, and the junctions that describe the transition from one mode or path to another. Additionally, there is a need for standards that facilitate the assessment of conditions and performance of these pathways. There is a need for real-time or operating standards that facilitate monitoring, regulation, and enforcement of automated and non-automated shared use vehicles and delivery vehicles at the curb and sidewalk in order to avoid obstructions or modal conflicts and ensure safety for all users.

There are numerous needs and standards gaps identified in the Outreach Report [OR] that address the lack of a standard for describing static and real-time conditions on sidewalks and other elements of the PROW as they relate to safe, comfortable, and accessible multimodal travel. For example, while numerous municipal agencies have developed and use a sidewalk quality index, Sidewalk Block

Pavement Condition Index¹¹, or Pavement Condition Index¹², no standard exists that meets the needs identified in the [OR]. Not only will this type of standard facilitate identifying conditions that will hinder mobility, it will ensure that accessible travel paths can be determined in real-time as part of a complete trip. Furthermore, the [OR] identifies a need for a comprehensive curb management standard. Such a standard would need to accommodate a variety of user needs such as those of last mile delivery and courier services; passenger loading and unloading zones (inclusive of accessibility requirements); and adjacent uses of the PROW (e.g., bike paths). It would also need to account for the anticipated automation of many of these curbside delivery and for-hire vehicle services.

The standardization of navigable paths in the PROW and indoors also offers opportunities to improve MAT through a variety of applications such as multimodal level of service measurements for bicycle and pedestrian navigation, use of electronic sensors to automate and standardize collection of physical infrastructure conditions data, and indoor and “small space” mapping models for collecting, navigating and rendering travel path information particularly junctions between modal paths (e.g., parking to sidewalk).

Stakeholders

Lead:

- SDO together with the US Access Board

Participants:

- Organizations currently working on these standards include:
 - FHWA Office of Planning, Human Environment, and Realty
 - Institute of Transportation Engineers (ITE)
 - International Parking and Mobility Institute (IPMI)
 - Alliance for Parking Data Standards (APDS)
 - Association for Unmanned Vehicle Systems International (AUVSI)
 - Customized Logistics and Delivery Association (CLDA)
 - APTA
 - North American Bikeshare Association (NABSA)
 - NACTO
 - SAE Mobility Data Collaborative

¹¹ Jangrak Kim, Daegeun Park, Youngchan Suh and Donghyuk Jung, “Development of Sidewalk Block Pavement Condition Index (SBPCI) using Analytical Hierarchy Process,” Sustainability 2019, 11(24), 7086, <https://www.mdpi.com/2071-1050/11/24/7086/pdf>

¹² ASTM D6433-20, Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys, ASTM International, West Conshohocken, PA, 2020, www.astm.org

- SharedStreets
- Open Mobility Foundation
- Harmonize Mobility
- American Society for Testing and Materials (ASTM)
- Disability and active transportation advocacy groups

Table 16. Action 2.4 Develop Specifications for PROW / Shared Use Paths and Conditions

Term	Action 2.4 Checklist
Short	<ul style="list-style-type: none"> • Extend/harmonize existing map data standards to include PROW / shared use paths, curb access with information on access • Develop performance specifications to collect mobility service provider and urban freight “last mile” delivery data • Develop performance condition index and testing protocols for sidewalk smoothness that supports people with mobility devices, bicycles, e-scooters, etc.
Mid	<ul style="list-style-type: none"> • Extend PROW Data models
Long	<ul style="list-style-type: none"> • Update Standards related to PROW / Shared Use Paths based on new technologies

Initiative 3: Technology and Infrastructure

Technology and infrastructure standards can apply uniform design principles to the construction or function of physical devices, tools, and facilities. Four priority actions are described in this section. They are:

Action 3.1 Uniform Transit Sign Manual

recommends the development of standards for transit signs that incorporate uniform design and universal form elements. These signs may also be forward looking in that they incorporate “smart technologies” for wayfinding and navigation (e.g., “talking signs” that incorporate C2X technologies).

Action 3.2 Wayfinding and Navigation Sensors and Communications covers sensors to detect physical impediments to travel along PROW and the communications technologies (e.g., WiFi, Bluetooth) to communicate these to VRUs. These include sensors that collect real-time operational status about the environment, facilities, barriers, elevator outages, and more, and the communications technologies.

Action 3.3 VRUs in the Connected to Everything Environment deal with developing and piloting standards to ensure that VRU personal safety devices are integrated into the C2X. A second set of technology standards address safety standards that detect and identify VRUs, particularly persons using assistive devices. Vehicle detection profiles currently developed focus on traditional VRUs – pedestrians and standard bicycles. The variety of VRUs – people using wheelchairs and mobility devices, wild animals, emergency and work zone personnel, bikes with trailers are not currently covered in these standards and there is safety data on the impact of their absence.

Action 3.4 Automated Wheelchair Securement recommends the development of standards for automated securement of wheelchairs in vehicles whether in buses, trains, or automated vehicles. Specifically, with the advent of automated vehicles, there need to be standardized requirements for automated wheelchair securement systems to be able to accommodate a wide variety of wheelchair types and form factors. These standardized requirements could be part of the design specs for a procuring organization (such as Amtrak, Greyhound, or a transit agency) to include when purchasing new equipment, and technology vendors could design against these requirements to achieve a critical mass of customers.

Action 3.1 Uniform Transit Sign Manual

Benefits and Justification:

A uniform transit sign manual would help transit agencies procure and deploy static and electronic signage consistent with transit agencies around the country. Wayfinding tools, such as informational and directional signage, and visual and tactile directional indicators provide directions for traveler services such as transit, parking, loading zones, elevators, fare payment areas, and information kiosks. Static and dynamic message signs are critical aids to provide static and real-time service information and to support accessible navigation through complex transportation facilities, locating transportation services such as ticketing and information booths, train platforms, bus stops, and pickup/drop-off locations. Even as other technology tools such as mobile apps and personal assistive devices (such as wheelchairs, wearable accessibility alerts, and canes) become more common, static and dynamic signs are still needed by most travelers. Currently, sign standards not only lack consistency with static and dynamic sign design (especially across different transit agencies), but also with digital sign standards and data exchange specifications for mobile apps and personal assistive devices.

Stakeholders –

Lead: Transportation Research Board (TRB), Federal Transit Administration (FTA)

Participate:

- Transit Agency staff
- Trade Organizations including American Public Transportation Association (APTA)
- Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)
- US Access Board
- Advocacy Groups representing vulnerable groups
- Sign vendors

Table 17. Action 3.1 Uniform Transit Sign Manual

Term	Action 3.1 Checklist
Short	<ul style="list-style-type: none"> • Initiate a TRB research effort to study requirements for transit signage <ul style="list-style-type: none"> ○ Consolidate existing standards that impact transit signage (both static and electronic) ○ Identify gaps in existing standards for transit signage ○ Develop recommendations for uniform transit signage
Mid	<ul style="list-style-type: none"> • Develop uniform transit sign manual • Develop and adopt guidance for uniform transit signage • Establish microgrant program to deploy signs based on Manual
Long	<ul style="list-style-type: none"> • Develop testing and conformance guidelines

Action 3.2 Wayfinding and Navigation Sensors and Communications

Benefits and Justification:

Without a standard to transmit and receive wayfinding requests from travelers for indoor and outdoor navigation, different approaches, communications protocols and technologies, messaging standards, and data descriptions are being deployed nationally and internationally. The potential for aiding people locally (without use of their mobile phone or other location tracking services) will support people who cannot afford expensive data packages and better protect their privacy. Standardizing protocols, messages and data will enable universal coverage anywhere nationwide, and provide for APIs and tools to be developed to accelerate adoption of the standards. The communications and sensor messages should be matched to the use cases and message sets developed in Action 2.2 Use Case and Data Exchange Specification Development.

Stakeholders

Lead: SDO such as SAE and Institute of Electrical and Electronics Engineers (IEEE), who develop communications and messaging standards (as well as mobile communications standards)

Participate:

- Private sector organizations representing end-user organizations: Hand-set and wearable manufacturers, building and facility trade-organizations (including transit agencies), software developers (particularly for mobile apps)
- Advocacy groups
- Connected Vehicle standards groups

Table 18. Action 3.2 Wayfinding and Navigation Sensors and Communications

Term	Action 3.2 Checklist
Short	<ul style="list-style-type: none"> • Initiate a use case and requirements study to identify scenarios for the functions, interfaces, performance, and security required by users of the standards. • Develop standards for communications between local transponders and VRUs for indoor and outdoor wayfinding and navigation including a profile that includes information layer and OSI layers 6 (presentation) and 7 (application). Topics to address include: <ul style="list-style-type: none"> ○ Presentation and Data layer standards ○ Message sets and dialogs ○ Communications profiles and gateways
Mid	<ul style="list-style-type: none"> • Complete standard development for information, application and presentation layers • Develop testing and conformance standards • Implement pilots to test standards
Long	<ul style="list-style-type: none"> • Develop guidelines and training for implementing standards including operations, maintenance and replacement • Develop OSS tools and APIs for accelerate deployment • Engage testing labs to certify compliance

Action 3.3 VRUs in the Connected to Everything Environment

Benefits and Justification:

Connected vehicle scenarios assume vehicles or roadside sensors will detect and be alerted to the presence of VRUs. This requirement works except that it leaves out the transition that occurs when travelers leave their vehicle to arrive at their destination. The connected traveler or collaborative ITS (C-ITS) environment provides a wealth of information to pedestrians, people on bikes, e-scooters, wheelchairs, workers in work zones, first responders, and more. As shared use paths become more congested with drones, pedestrians, runners and MMVs, the need for connections to everyone will become more critical. Some work is underway to connect personal safety devices (PSD) to the connected vehicle roadside equipment (e.g., USDOT's Connected Vehicle Pilots in New York City and Tampa, Florida), however, there is no reference architecture for how that will happen. Additionally, ISO architecture standards, particularly ISO 24102 series on Communications Access for Land Mobiles (CALM) provides a framework for communications pathways and nodes, although mobile and wearables may be included, they and their use by VRUs are not represented. The connected environment not only serves safety applications; it also provides wayfinding and navigation, provides information on potential collisions with light weight vehicles (e.g., MMV) and non-motorized vehicles, and potentially identifies obstacles for travel on shared use pathways (e.g., parked vehicle in bike lane, object stopped in sidewalk limiting passage for wheelchairs). The use cases and examples included in all the connected vehicle standards would benefit by including scenarios with VRUs. The communications standards would benefit by showing how PSDs interconnect to the Connected Vehicle communications infrastructure. This action identifies key existing and emerging standards activities where including advocacy groups, addressing

VRU scenarios, and extending the technology to include PSD would make a significant difference to encourage products and applications for MAT.

Stakeholders

Lead:

- SAE (for CV architecture and message standards) and ISO TC 204 WG 19
- IEEE (for communications standards) and ISO TC 204 TC WG 18

Participate

- Advocacy groups
- SAE C2X committee
- IEEE CV standards groups
- ITE Connected Intersections Project
- ISO TC 173 SC 1 Wheelchairs (liaison)

Table 19. Action 3.3 VRUs in the Connected to Everything Environment

Term	Action 3.3 Checklist
Short	<ul style="list-style-type: none"> • Connected PSD: <ul style="list-style-type: none"> ○ Develop standards for BSM/PSM for non-light duty vehicles within the SAE V2X Steering Committee to enable full-scale suite of vehicle safety applications that is inclusive of all vehicle types, including motorcycles and mopeds. ○ Develop performance requirements for Personal Safety Message (PSM) trajectory information accuracy for MMV vs. active modes (walking, non-powered MMV and assistive devices) ○ Review and include mobile device interconnection profile with SAE C2X ○ Develop CV gateway standard for inclusion of mobile device communications into the C-V2X ○ Prototype PSD for wheelchairs (involve ISO TC 173 SC 1 Wheelchairs) in the pilot • Connected Crosswalks <ul style="list-style-type: none"> ○ Develop reference implementation recommendations for standards that is consistent with USDOT “Complete Trips” vision; this may include signalized intersection applications (SAE J2945/B) through SAE Infrastructure Applications Committee to reduce the number of options for both over the air and the message contents, including the addition of crosswalks to MAP messages and clarify SPaT and road geometry information ○ Work with ITE to include VRUs in the Connected Intersections Project • Inclusion with Existing Standard Efforts <ul style="list-style-type: none"> ○ Promote inclusion of Advocacy groups in the update of SAE J2945 Part 4 Road Safety Applications¹³ and Part 9 Vulnerable Road User Safety Message Minimum Performance Requirements • Develop standards for comprehensive profiles of VRU types within SAE Active Safety Systems Standards Committee and/or ISO/TC 204
Mid	<ul style="list-style-type: none"> • Deploy pilots to test inclusion of mobile devices • Update PSD standards to include wearables • Develop guidance on applying standards to mobile and wearables • Develop standards for cooperative perception within SAE V2X Steering Committee to define and address needs of cooperative driving automation use cases such as status and intent sharing features (e.g., pedestrian object tracking)
Long	<ul style="list-style-type: none"> • Update Standards related to Personal Safety Devices based on new technologies

Action 3.4 Automated Wheelchair Securement

Benefits and Justification:

Standardized wheelchair tiedown and occupant restraint systems (WTORS) are necessary for travelers with wheelchairs to safely enjoy the benefits of AVs. Currently there are a variety of WTORS used by on vehicles transporting wheelchairs but as mentioned previously, there is little consistency with the

equipment, processes, quality and even availability. Furthermore, nearly all WTORS today require a second person to assist with the securement, which does not work with independent travel on AVs, and the wide variety of WCs make it difficult to develop a system that delivers universal design. This has led to greater aftermarket costs for the end-user, lack of occupant safety validation, and complexity in matching WTORS to wheelchairs. Furthermore, there are existing WTORS that have gained industry interest, such as those defined in RESNA WC18¹⁴ and WC19¹⁵.

Stakeholders –

Lead: Co-leadership by automotive and assistive technology SDOs, such as, SAE International and Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)

Participants:

- Assistive technology manufacturers
- Automotive OEMs
- Disability Advocacy Groups
- Shared (automated) fleet operators
- Appropriate APTA Committees (e.g., Standards and Paratransit)
- Relevant USDOT modal administrations

¹³ SAE J2945/4 – Road safety applications within SAE V2X Infrastructure Applications Committee: The RSA standard will define a Road Safety Message (RSM) and corresponding data objects that support numerous safety-related events, e.g., work zones, curve speed warning, queue warning, school zones, etc.

¹⁴ <http://wc-transportation-safety.umtri.umich.edu/wts-standards/wc18-wtors>

¹⁵ <http://wc-transportation-safety.umtri.umich.edu/wts-standards/wc19-wheelchairs>

Table 20. Action 3.4 Automated Wheelchair Securement

Term	Action 3.4 Checklist
Short	<ul style="list-style-type: none"> • Research best approaches for standards in this area including identifying specifications of current WTORS to provide operators and users with information about the systems that exist, how they are used, how large the hooks are and whether they'll work with specific devices, etc.
Mid	<ul style="list-style-type: none"> • Collaboration between automotive and assistive technology SDOs (e.g., SAE and RESNA) to jointly develop standards for design considerations for affixing wheelchair tiedown and occupant restraint systems (WTORS) to passenger vehicles, light duty vehicles, and shuttles seating up to 7 occupants
Long	<ul style="list-style-type: none"> • Develop testing and compliance standards • Develop implementation guides including operations, maintenance and replacement lessons learned (e.g., the type and amount of equipment needed for safe transport)

Initiative 4: Training and Guidance

One critical aspect of standards development is the adoption and use of new standards by practitioners. This requires providing training and guidance to ensure that practitioners understand and have the ability to apply new standards. The USDOT established an exemplary ITS Standards Program in 1996 to not only provide guidance and training on ITS standards, but to “encourage the widespread use of ITS technologies in our Nation’s surface transportation systems.”¹⁶ The ITS Professional Building Capacity Program is responsible for the development and delivery of ITS standards training “for practitioners in state and local highway agencies and transit agencies who seek the skills needed to procure, test, implement, and operate standards-based ITS systems and devices. Consultants, system designers, integrators, and testers will also find the training informative.”¹⁷

There is a need to include MAT standards in the ITS PCB program standards training to:

- Educate a wide variety of MAT stakeholders and system designers/integrators;
- Assist practitioners in interpreting and understanding the standards; and
- Identify any unintended consequences associated with using MAT standards, if any.

Further, implementation guidance could be developed in each of the major MAT standards areas to provide examples of implementing MAT standards. Implementation guidance could be developed by USDOT or ISO and vetted through MAT practitioner organizations. The implementation guidance would

¹⁶ <https://www.standards.its.dot.gov/About/AboutITSStandardsProgram>

¹⁷ https://www.pcb.its.dot.gov/stds_training.aspx

not prescribe just one approach to implementing a MAT standard and entities may choose alternative approaches that better fit their situation. These efforts are built into the recommendations for the two actions recommended in this initiative. They include:

Action 4.1 Training and Guidance on Standards Implementation covers training and guidance documents that support deployment of the standards.

Action 4.2 Develop a Resource Library for MAT Standards recommends that a database of standards, lessons learned, and implementation guidance be developed to support deployment activities as well as promote extensions and expansion of the existing and emerging standards.

Action 4.1 Training and Guidance on Standards Implementation

Benefit and Justification:

The benefits of providing training and guidance on MAT standards implementation are threefold: (1) to ensure that potential MAT standards users have a comprehensive understanding of the standards and how they can be adopted to, among other benefits, reduce the life cycle costs of MAT systems; (2) to encourage agencies, and system designers and developers to incorporate MAT standards into existing system upgrades and enhancements, and into new systems; and (3) to support the development and use of MAT data exchange specifications.

Further, providing training and guidance to meet at least two of the Strategy criteria: directly contributing to (1) the long-term sustainability of standard deployments; and (2) the opportunity for wide deployment (since training and guidance can include the description of testing procedures and tools to support validation, collection, and dissemination of data in the appropriate formats).

Lead: USDOT ITS PCB Program and MAT Program Team (see Action 1.3)

Participants:

- US Access Board
- Relevant Modal Administrations and USDOT offices and centers handling data
- SDOs developing standards
- End-User / Advocacy Groups that represent end-user communities such as vulnerable travelers, industry consortium, vendors, and consultants

Table 21. Action 4.1 Training and Guidance on Standards Implementation

Term	Action 4.1 Checklist
Short	<ul style="list-style-type: none"> • Identify potential training about MAT standards and where guidance is needed in the six MAT standards areas • Initiate USDOT ITS Professional Capacity Building curriculum for the mobility platform standards (begin with SAE standards for MMVs) • Develop guidance on using CAV Standards for VRUs including mobile devices and wearables • Develop guidance on using CAV standards for MMVs
Mid	<ul style="list-style-type: none"> • Develop selected MAT standards training modules and guidance • Develop guide for implementing indoor navigation technology and information provisions
Long	<ul style="list-style-type: none"> • Update existing MAT standards training modules and develop new modules if new MAT standards developed • Update existing MAT standards guidance and develop new guidance if new MAT standards developed

Action 4.2 Develop a Resource Library for MAT Standards

Benefits and Justification:

Provide a one-stop knowledge hub for practitioners looking to explore, adopt, and implement MAT standards. The online resource library would serve as a comprehensive library of existing and emerging standards in MAT and related training and capacity building programs for implementation of standards. The resource library would be publicly available at no cost to users and remain agnostic to technology and home organization of the standards. Analyses of interoperability and relationship between various standards would be part of the library. A non-profit organization with extensive reach in the mobility standards realm in standard development, end users (manufacturers, operators and application developers) and capacity building, such as SAE International and ITE, may be best suited to embark on this action.

Stakeholders

Lead: USDOT MAT Initiatives (see Action 1.3 for recommendation)

Participants:

- USDOT Grantees
- SDOs developing standards

Table 22. Action 4.2 Develop Resource Library for MAT Standards

Term	Action 4.2 Checklist
Short	<ul style="list-style-type: none"> • Implement a knowledge body (library) with MAT standards and create an online platform to serve as the resource library • Establish a knowledge body (library) for CV standards for VRUs Implementation including workshops to promote standards and deployment tools
Mid	<ul style="list-style-type: none"> • Develop playbook for implementing standards • Develop lessons learned from initial deployments
Long	<ul style="list-style-type: none"> • Provide technical support for deploying standards to public agencies

Initiative 5: Innovation and Research

Benefits and Justification:

A significant set of innovation and research is underway to explore Complete Trip scenarios, integration of mobile devices with the CV environment, improving location accuracy and trajectory information using mobile devices, measuring roughness on shared use paths for people with wheelchairs, and personalize better, connected trips for each traveler. The research and innovations help promote new approaches to solve problems, but most are never incorporated into standard documents that help to normalize and accelerate dissemination of better practices. The Innovation and Research initiative is included to ensure that there is a path from research to standards. The Knowledge Body / Library from Action 4.2 will help match research and innovation to standard initiatives. For example, USDOT has a list of research and innovations related to pedestrian safety¹⁸. Many of these will become single tests though they may provide great benefit to standard development. A plan or method to map these innovations to standards and emerging standard development activities would greatly improve the standard development process to incorporate best practices.

Stakeholders

Lead: USDOT

Participants:

- USDOT Grantees
- University Transportation Research Centers

¹⁸ See Vehicle to Pedestrian Technical Scan Summary: https://www.its.dot.gov/press/2015/v2p_tech.htm

- Transportation Research Board

Table 23. Action 5.1 Innovation and Research

Term	Action 5.0 Checklist
Short	<ul style="list-style-type: none"> • Identify areas where more research is necessary to develop standards for Complete Trips. Examples: <ul style="list-style-type: none"> ○ Curb and sidewalk access congestion management ○ Tools for collecting sidewalk and curb condition collection (static and dynamic) ○ Traveler behavior prediction using mobile device / wearables ○ Vibrotactile (haptic) sensor functionality • Develop plan for research to feed standards efforts and include in the Knowledge Body library (Action 4.2)
Mid	<ul style="list-style-type: none"> • Continue to maintain and sustain database with research and innovation projects and standards efforts
Long	<ul style="list-style-type: none"> • Continue to maintain and sustain database with research and innovation projects and standards efforts

Chapter 5. Next Steps

As MOD is increasingly implemented by public and private mobility service providers, the development and use of MAT standards will greatly benefit future system deployments in terms of data sharing, product creation, privacy requirements, and other key considerations. To ensure universal and inclusive design and accelerate deployment of fully accessible systems, it is important that these standards derive from the needs of all travelers, including persons with disabilities, older adults, and other vulnerable road user groups. Such steps will help ensure high-quality, interoperable, relevant, and lower cost connected mobility services for everyone.

This document provides actionable near, mid, and long-term recommendations intended to address gaps and harmonize existing and emerging standard efforts to support these outcomes. The recommendations can be implemented with encouragement and support by the USDOT for key stakeholders – standard development organizations, trade associations, advocacy groups, crowdsourcing, and private sector organizations. Further, the Strategy supports a coordinated and comprehensive approach to MAT standards development and deployment necessary to fully bridge these gaps and achieve the complete trip vision.

While the Strategy charts a path forward for MAT standards, it is important to remain nimble and flexible in implementing these recommendations. Not only due to the rapid advances in technology, but as the massive disruptions of the COVID-19 pandemic have demonstrated, there are potential current and future risks that may alter thinking about travel behavior, safety and security, and mobility needs. Many of these risks have important implications for MAT standard developments and for the transportation industry generally. As such, while the action lists should form a good starting point for stakeholder coordination, it is anticipated that this document and related supporting documents such as the Std Update should be reviewed and updated over time. Further, USDOT may wish to track progress of the short-, mid-, and long-term recommendations in this Strategy and take necessary steps to support their achievement. Integration of the Strategy recommendations in complementary USDOT program areas would also help bolster achievement of these actions.

Appendix A. Acronyms

Term	Description
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
ANSI	American National Standards Institute
API	Application Programming Interface
APTA	American Public Transportation Association
ATTRI	Accessible Transportation Technologies Research Initiative
AV	Automated Vehicle
B2B	Business to Business
CALM	Communications Access for Land Mobiles
CCPA	California Consumer Privacy Act
CEN	European Committee for Standardization
C-ITS	Collaborative Intelligent Transportation Systems
C2X	Connected Vehicles to Everything
FLA	Forward Looking Assessment
GBFS	General Bikeshare Feed Specification
GTFS	General Transit Feed Specification
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITSJPO	USDOT Joint Program Office on Intelligent Transportation Systems
MaaS	Mobility as a Service
MAT	Multimodal and Accessible Travel
MATSA	Multimodal and Accessible Travel Standards Assessment
MDS	Mobility Data Specification
MMV	Micromobility Vehicles
MOD	Mobility on Demand
MP	Mobility Platform
NeTEx	Network Timetable Exchange
ORAD	On-Road Automated Driving
OSI	Open Systems Interconnection
OSS	Open Source Software
PII	Personally Identifiable Information
PROW	Public Right of Way
PSD	Personal Safety Devices
RESNA	Rehabilitation Engineering and Assistive Technology Society of North America
SDO	Standards Development Organization

Term	Description
TC	Technical Committee
TOMP-API	Transport Operator to MaaS Provider API
USDOT	U.S. Department of Transportation
VRU	Vulnerable Road User
WaN	Wayfinding and Navigation
WZDx	Work Zone Data Exchange

Appendix B. Stakeholders

Outreach was organized into two stakeholder categories: Outreach to End-User Stakeholders and Outreach to Standards Organizations.

End-User Stakeholder Groups

- Disability Advocacy Organizations
 - American Council of the Blind (ACB)
 - American Foundation for the Blind (AFB)
 - Christopher and Dana Reeve Foundation
 - Easter Seals - Project ACTION
 - Hearing Loss Association of America (HLAA)
 - National Association of the Deaf (NAD)
 - National Council on Independent Living (NCIL)
 - National Federation of the Blind (NFB)
 - The Arc
 - United Spinal Association
- Transportation Organizations and Trade Associations
 - American Association of State Highway and Transportation Officials (AASHTO)
 - American Public Transportation Association (APTA)
 - Association for Unmanned Vehicle Systems International (AUVSI)
 - Association of Commuter Transportation (ACT)
 - Automobile Alliance
 - Community Transportation Association of America (CTAA)
 - ITS America / MOD Alliance
 - Mineta Transportation Institute/Landis + Evans
 - National Aging and Disability Transportation Center (NADTC)
 - National Association of City Transportation Officials (NACTO)
 - North American Bikeshare Association (NABSA)
 - Rehabilitation Engineering Research Center on Accessible Public Transportation (RERCAPT)
 - Secure Technology Alliance (STA) Transportation Group
 - SharedStreets
 - Shared-Use Mobility Center (SUMC)
 - Transportation Research Board (TRB)
- Other Stakeholders – including government organizations, vendors, advocacy organizations or groups
 - American Association of Retired Persons (AARP)
 - American Planning Association (APA)
 - BestMile
 - Carnegie Mellon University - Robotics Department
 - Coord (part of Alphabet / Google)
 - Georgia Tech - Apps for Older Adults
 - Innovations in Technology Inc. (INIT)
 - Mobile Payment App vendors (e.g., Masabi, Bytemark, moovel) and fare collection vendors (e.g., Cubic, INIT)

- National Association of Area Agencies on Aging (n4a)
- National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR)
- Partners for Livable Communities
- Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)
- US Department of the Interior / United States Geological Survey (USGS)
- U.S. Access Board
- U.S. DOT Accessible Transportation Technologies Research Initiative (ATTRI)
- World Wide Web Consortium (W3C)

Standards Organizations

- International SDOs
 - ISO TC 204
 - European Committee for Standardisation (CEN)
 - European Committee for Electrotechnical Standardisation (CENELEC)
 - SAE International
- National SDOs
 - America Public Transportation Association (APTA)
 - Institute of Transportation Engineers (ITE)
 - National Electrical Manufacturers Association (NEMA)
 - Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)
- Community, Consortium, Non-Profit, and Trade Associations
 - Mobility as a Service (MaaS) Alliance
 - Open Mobility Foundation
 - SharedStreets
 - TRB TCRP Report 210 - Development of Transactional Data Specification for Demand-Responsive Transportation (2019)
 - Mobility Data Collaborative (SAE Industry Technologies Consortia)
 - MobilityData (Canadian based organization shepherding tools and guidance on family of GTFS and GBFS)

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