# Phase 1 Enabling Technology Readiness Assessment

## California Association for Coordinated Transportation ITS4US Deployment Project

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**Final Report — November 15, 2021**
**FHWA-JPO-21-886**

COMPLETE TRIP
ITS4US

U.S. Department of Transportation

Produced by California Association of Coordinated Transportation ITS4US Deployment Program, Phase 1
U.S. Department of Transportation
Intelligent Transportation Systems Joint Program Office
Federal Highway Administration
Office of the Assistant Secretary for Research and Technology
Federal Transit Administration

# Notice

## Technical Report Documentation Page

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| **FHWA-JPO-866** | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| **Phase 1 Enabling Technology Readiness Assessment**<br>**California Association for Coordinated Transportation ITS4US Deployment Project** | November 15, 2021 |
| | **6. Performing Organization Code** |

| 7. Author(s) | 8. Performing Organization Report No. |
|---|---|
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| 9. Performing Organization Name and Address | 10. Work Unit No. (TRAIS) |
|---|---|
| California Association for Coordinated Transportation – CALACT<br>4632 Duckhorn Drive, Sacramento, CA 94583 | **11. Contract or Grant No.**<br>693JJ321C000007 |

| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered |
|---|---|
| U.S. Department of Transportation<br>ITS Joint Program Office<br>1200 New Jersey Avenue, SE<br>Washington, DC 20590 | **14. Sponsoring Agency Code**<br>HOIT-1 |

**15. Supplementary Notes**

Robert Sheehan, COR

**16. Abstract**

This project aims to address the need for riders who use demand-responsive services, rural riders, and riders with disabilities to have equal access to the real-time trip planning technologies already available for fixed-route transit, as well as Transportation Network Companies. Fixed-route transit rider information has developed quickly in the last 15 years, but is generally limited to smartphone users in urbanized areas. General Transit Feed Specification (GTFS) data, the most common transit schedule exchange data format, does not require the inclusion of accessibility information that ensures riders with vision, mobility, hearing, and cognitive disabilities can access the transit service information. The purpose of this document is to present and describe the various technologies required for this project. This document provides an overview of the technologies, a description of each technology's readiness level, a list of potential risks, and a discussion of mitigation strategies to address those risks.

The Complete Trip - ITS4US Deployment Program is a $40 million multimodal effort, led by the ITS JPO and supported by OST, FHWA, and FTA to identify ways to provide more efficient, affordable, and accessible transportation options for underserved communities that often face greater challenges in accessing essential services. The program aims to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers.

| 17. Keywords | 18. Distribution Statement |
|---|---|
| ITS4US; Complete Trip; Deployment; ITS; Intelligent Transportation Systems; California; Oregon; Washington; Data; Transit; GTFS | |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| | | | |

# Revision History

| Name | Date | Version | Summary of Changes | Approver |
|---|---|---|---|---|
| Kaiomi Inniss, MobilityData | 30 August 2021 | 0.1 | Initial Draft | Thomas Craig, CALACT |
| Kaiomi Inniss, MobilityData | 15 November 2021 | 1.0 | Final Draft | Thomas Craig, CALACT |

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# 1. Introduction

A primary objective of the Complete Trip-ITS4US Deployment program is to deploy new and innovative solutions to help underserved populations perform a complete trip. The purpose of the Enabling Technology Readiness Assessment (ETRA) is to identify the technologies needed to implement these solutions and to evaluate the availability of these technologies.
Section 1 provides a list of the identified necessary technologies. Section 2 describes the "readiness level" of each technology. Section 3 discussed potential risks and mitigation strategies for those risks.

## 1.1. Intended Audience

The intended audience of this document is the CALACT team, including its subcontractors and stakeholder subcommittee chairs and members, as well as the USDOT program management team. Academic and practitioner stakeholders and those wishing to replicate portions of the work done in this project who may find this document useful are considered as well.

## 1.2. Project Background

The CALACT project addresses the clear need for riders who use demand-responsive services, including riders with disabilities, to have equal access to the real-time trip planning technology that is already available for urban fixed-route transit. Nearly 300 of the over 500 transit operators in California, Oregon, and Washington deliver a form of demand-responsive service.[1] Rider characteristics of these services likely differ substantially from those on fixed-route services as rural residents and people with disabilities are more likely to be low-income, unable to use fixed-route services due to disability, and/or are living in a physically isolated environment.

The demand-response systems themselves offer a lower quality of rider experience, where would-be passengers must find a transit provider that will serve their needs, call a dispatch system to plan and reserve their trip, requiring a long lead time (typically at least a day in advance), and allowing little room for flexibility. The trip planning experience of demand-response systems is further and uniquely burdened by a complex web of determining operator coverage area, for what qualifications that operator or specific service within that operator's service menu

[1] Numbers calculated based on internal lists of agencies and metadata provided by ODOT, WSDOT, and Caltrans.

they qualify, if the operator has availability, if they need to pay and how. Unlike fixed route services, which have a well-established data standard and a stable industry of third-party trip planning services, and private Transportation Network Companies (TNCs), which produce their own seamless and instantaneous booking and payments flows, demand-responsive transit lacks the technical solutions which could ease these burdens for their riders. There's no comparable desktop or smartphone experience and no other innovations which exist to untangle these webs of availability, reservations, or payments.

Most fixed route users in the three-state region have access to real-time information about transit services through any mobile device. However, very few users have that information about public demand-responsive transit, and none have that information except through custom proprietary systems implemented at a few local agencies. Further, users of fixed-route services who would like more access to details regarding the transit system accessibility features and other amenities often cannot easily find that information.

The particular underserved communities the project focuses on are people with mobility disabilities, people with vision disabilities, people with cognitive and developmental disabilities, people with hearing disabilities, older adults, low-income populations, rural residents, veterans, and people with limited English proficiency.

This project is one of five deployments of the Complete Trip - ITS4US Deployment Program, led by the Intelligent Transportation Systems Joint Programs Office (ITS JPO) and supported by Office of the Secretary (OST), Federal Highway Administration (FHWA), and Federal Transit Administration (FTA). These deployments were selected to showcase innovative business partnerships, technologies, and practices that promote independent mobility for all travelers regardless of location, income, or disability. The Complete Trip - ITS4US Deployment Program is carried out in three phases over five years: Concept Development (current phase), Design and Testing, and lastly Operations and Evaluation. There is a post-deployment operations and maintenance phase for an additional five years. The intended outcomes for the CALACT deployment are to improve the user experience and cost efficiency of demand responsive transit for riders at agencies throughout the Washington, Oregon, and California.

Project partner (subcontractor) organizations include:

- Oregon Department of Transportation (ODOT): Agency outreach in Oregon, member of PMT, transit directory product manager
- Washington Department of Transportation (WSDOT): Agency outreach in Washington, member of PMT, transit analysis product manager
- California Department of Transportation (Caltrans): Agency outreach in California, member of PMT, payments product manager
- Washington State Transit Association (WSTA): Support agency outreach in WA and assist with event coordination
- Trillium, an Oregon small business: Concept design, report writing and product management support

- Compiler LA, a California small business: Software systems requirements and data management lead
- Tamika L. Butler Consulting, a California small business: Internal evaluation and stakeholder engagement
- Mark Wall Associates, a California small business: Agency outreach and support for reporting and project administration
- Estolano Advisors, a California small business: Agency and stakeholder outreach support
- California Partners for Advanced Transportation Technology at UC Berkeley: Project evaluation and stakeholder safety and human use leads
- MobilityData IO, a Canadian nonprofit: Data specification development and technology readiness assessment lead
- Transit, a Canadian private corporation registered for business in the US: Technical advice on customer interface needs and development
- Navilens, a Spanish private corporation registered for business in the US: Digital accessible signage and text to speech product leads
- Google, an American public corporation (unfunded): Participation in an advisory and user testing coordination role

## 1.3. Scope

The ETRA identifies the technological subcomponents (“technologies”) to be individually bought, built, and/or integrated into the system to be developed by the CALACT ITS4US deployment. Each technology is identified, along with potential approaches to development or procurement; the risks associated with those technologies are itemized; each technology is assessed for the degree of readiness to deploy. Technologies are assessed according to the User Needs identified in the Concept of Operations and the requirements defined in the System Requirements Specification. The processes used to develop these technologies into the system to be deployed is described in the Systems Engineering Management Plan.

## 1.4. Goals and Objectives

The ETRA will demonstrate how the enabling technologies (ETs) are addressing the user needs and requirements identified in the Concept of Operations (“ConOps”) and System Requirements Specification (SyRS). By conducting an ETRA, the project will be able to identify the technologies’ readiness for deployment and how to manage and address risk. Documenting the maturity of the

technologies will enable others to build upon the investments made in this project to progress toward Complete Trip goals more effectively in future deployments.

## 1.5. References and Applicable Documents

This document utilizes information and processes defined in the following documents:

- Concept of Operations (ConOps), CALACT
- System Requirements (SyRS), CALACT
- ISO Standard 16290 Space systems, NASA

# 2. Identify Enabling Technologies

## 2.1. Technology Readiness Framework

The Technology Readiness Framework will be based on the ISO Standard 16290 Space systems by NASA. The Technology Readiness Levels (TRLs) are used to assess the maturity level of a particular technology. Each technology is evaluated using the parameters for each technology level and subsequently assigned a rating based on its progress. The criteria for the ISO Standard 16290 Space systems are as follows:

- TRL 1: Scientific research is beginning, and those results are being translated into future research and development.
- TRL 2: The basic principles have been studied and practical applications can be applied to those initial findings. The technology is speculative as there is little to no experimental proof.
- TRL 3: Active research and design begins and generally both analytical and laboratory studies are required at this level to see if a technology is viable and ready to proceed further through the development process. Often in TRL 3, a proof of concept model is constructed.
- TRL 4: Multiple pieces are tested with one another.
- TLR 5: A continuation of TRL 4, however, a technology at 5 is identified as a prototype technology and must undergo more rigorous testing than technology that is only at TRL 4. Simulations should be run in environments that are as close to realistic as possible.
- TRL 6: A TRL 6 technology has a fully functional prototype or representational model.
- TRL 7: Technology requires that the working model or prototype be demonstrated in a space environment.
- TRL 8: Technology that has been tested and is “flight qualified” and it is ready for implementation into an already existing technology or technology system.
- TRL 9: A technology that has been “flight proven” during a successful mission.

We are using this standard because it is well established and has been translated into terminology that works for other operational environments besides space. For example, in its simplest terms, the TRLs can be defined as:

- TRL 1 – Basic principles observed
- TRL 2 – Technology concept formulated

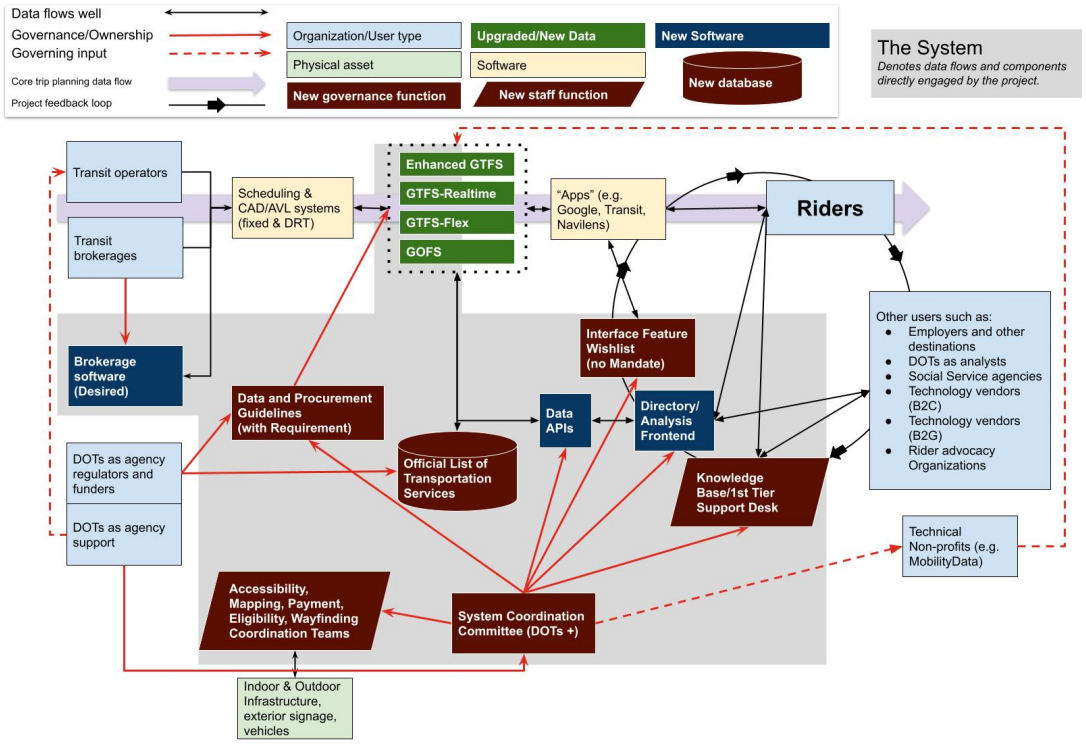
- TRL 3 – Experimental proof of concept
- TRL 4 – Technology validated in lab
- TRL 5 – Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – System prototype demonstration in operational environment
- TRL 8 – System complete and qualified
- TRL 9 – Actual system proven in operational environment

The CALACT project proposes a governance framework to support the standardization of data published by transit services throughout a large region and does not only consist of hardware and software subcomponents that are most easily evaluated within the Technology Readiness Framework being used. Some system technologies such as data standards or an interstate partnership document fit into the framework but are not typically evaluated in this fashion. Other technologies such as internet service would typically be decomposed into more specific technologies, but are evaluated at a higher level because they are not directly part of the system and low-level analysis of every technology involved would be impractical and unhelpful.

## 2.2. Enabling Technologies Inventory

This section describes all the ETs expected to be deployed in each system subcomponent, while identifying the integration and procurement of each ET. This section also traces each ET to a user need as specified in the ConOps. The system subcomponents were taken directly from the Proposed System Diagram (Figure 1). The system subcomponents consist of upgraded/new data, new software, existing software, new governance functions, and new staff functions. Although not strictly contained within the system of interest, Transit data standards, Apps, and Scheduling/CAD/AVL software systems are listed below as technologies because of their close relation to the system and their importance to the risk assessment of the system.

**Figure 1. Proposed System Diagram**




## 2.2.1. ET #1: Transit Data Standards

### *Description*

Transit data standards allow transit data operators to publish their data in a format that can be utilized by various software applications. It is a common format for data that defines the overall structure a data producer must adhere to, along with the types and formats of the data elements that fill the structure, with the goal that the data can be reliably interpreted by a data consumer. General Transit Feed Specification (GTFS) is the most commonly used standard by public transit agencies and operators. There are also a number of extensions to the specification that allow for additional data to be represented.

Transit Data Standards are a key component of the proposed system, although they are also governed globally through a process outside of the system. There are multiple potential data standard extensions which make up this component, but they are considered collectively in this section as the lines between the individual technologies is not absolute, and there are many such technologies.

Enabling Technologies for the Transit Data Standards System Subcomponent:

- Fixed route transit schedule information standard
- Access/Fare discount entitlements standard
- Fare cost standard
- Fixed route transit real time information standard
- Abbreviation translation standard
- Pedestrian pathways within stations standard
- Vehicle description standard
- Increased visibility on accessible transportation services standard
- Demand responsive transit standard

***Integration***

Data standards are necessary for a variety of elements of the overall system , such as booking, payment, information on demand-responsive and paratransit services with flexible schedules and routes, accessibility, and wayfinding tools. Some data standards like GTFS-Schedule and GTFS-Realtime are already in widespread use, while others like GTFS-Vehicles have been drafted but are not in use.

***Procurement***

The data standards are grouped in this section but each one is its own enabling technology for the system component. Each data standard is discussed individually in Section 3 as they all have varying levels of readiness. The following are the potential products:

- Fixed route transit schedule information standard - **GTFS Schedule (core)**
- Access/Fare discount entitlements standard - **GTFS-Eligibilities**
- Fare cost standard - **GTFS-Fares**
- Fixed route transit real time information standard - **GTFS-Realtime**
- Abbreviation translation standard - **GTFS-TextToSpeech**
- Pedestrian pathways within stations standard - **GTFS-Pathways**
- Vehicle description standard - **GTFS-Vehicles**
- Increased visibility on accessible transportation services standard - **GTFS-Capabilities**
- Demand responsive transit standard - **GTFS-Flex, General On-demand Feed Specification (GOFS)**

### *Traceability*

Below are the user needs and system requirements expected to be met in part through the support of transit data standards. Because of the centrality of transit data standards to the effect of the proposed system, very many of the identified user needs could in part be traced to these technologies.

**Table 1: ET #1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-02 - Clear governance | M02-1 | The system shall promote the use of data standards that align with the Mobility Interoperability Principles (link), such as GTFS and GTFS Realtime. |
| OP-02 - Booking through rider apps | O02-1 | The system shall promote the use of a data standard that allows users to book demand responsive trips through third party trip planning applications. |
| OP-02 - Booking through rider apps | O02-1.1 | The system shall promote the use of a data standard that allows users to book demand responsive trips through a third party application by deeplinking to a different application for the final booking confirmation. |
| OP-02 - Booking through rider apps | O02-1.1 | The system shall promote the use of a data standard that allows users to book demand responsive trips entirely within a third party application through the use of APIs. |
| OP-02-1 - Time of booking | O02-1-1 | The system shall promote the use of a data standard that allows operators to define allowed booking times for demand-responsive services. |
| RID-01 - Discover DR | R01-1 | The system shall promote the use of a data standard that describes available demand-responsive trips for discovery in trip planning applications. |
| RID-01-1 - Book in advance | R01-1-1 | The system shall promote the use of a data standard that allows operators to define allowed advance booking requirements for demand-responsive services. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-01-3 - DR travel time | R01-3-1 | The system shall promote the use of a data standard that supports modeling of expected travel time for demand-responsive trips. (i.e.: mean_duration_factor in GTFS-flex specification) |
| RID-01-3 - DR travel time | R01-3-2 | The system shall include as part of published best practices that operators publish data which allows a consuming application to calculate estimated travel time for demand-responsive trips. |
| RID-01-4 - DR wait time | R01-4-1 | The system shall promote the use of a data standard that supports modeling of expected wait time prior to the beginning of the trip for demand-responsive trips. |
| RID-01-4 - DR wait time | R01-4-2 | The system shall include as part of published best practices that operators publish data which allows a consuming application to calculate estimated wait time for demand-responsive trips. |
| RID-03 - Eligibility process | R03-1 | The system shall promote the use of a data standard that supports eligibility program information and eligibility verification requirements for transit services. |
| RID-04 - Hear text annunciation | R04-1 | The system shall promote the use of a data standard that supports including Text-to-Speech information to facilitate improved audio annunciation by data consuming systems. |
| RID-04-1 - Audio option | R04-1-1 | The system shall promote the use of a data standard that describes alert, wayfinding, or service regulation information. |
| RID-14 - Cost of service | R14-1 | The system shall promote the use of a data standard that describes fares including passes, fare-caps, discounted or subsidized fares, and temporary price reductions. |
| RID-14-1 - Standard payment media | R14-1-1 | The system shall promote the use of a data specification that describes payment media. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-19 - Device accessible | R19-1 | The system shall promote the use of a data standard that describes vehicle capabilities (capabilities to support wheelchair, bike, or other mobility devices). |
| RID-19-1 - Space for mobility device | R19-1-1 | The system shall promote the use of a data standard or align with emerging data standards that describes real-time vehicle capabilities (capabilities to support wheelchair, bike, or other mobility devices). |
| RID-19-2 - Pathways in advance | R19-2-1 | The system shall promote the use of the GTFS-Pathways data specification (https://gtfs.org/reference/static/#pathwaystxt). |
| RID-20-1 - Preferred language | R20-1-1 | The system shall provide interfaces which are internationalized (i18n) to support the loading of translations in any language. |
| RID-20-1 - Preferred language | R20-1-2 | The system shall promote the use of the GTFS-Translations specification (http://gtfs.org/reference/static/#translationstxt). |
| MUL-04 - Two-way exchange in booking | M04-1 | The system shall promote the use of a data standard that models two-way real-time data exchange between demand-responsive scheduling applications and trip planning applications for the purpose of increasing the quality of trip travel start time and travel time estimates. |
| OP-05 - Changes to road network | O05-1 | The system shall promote the use of a data standard that models unplanned real-time service changes and other information which facilitates adjustment of services to meet real-time conditions on the ground. |
| OP-07 - Integrated fare payment | O07-1 | The system shall promote the use of a data standard that allows operator payment systems to enable the sales of fares through trip planning apps. |
| OP-08 - Different types of trips | O08-1 | The system shall promote the use of a data standard that allows operators to reflect and restrict as needed their current vehicle capacity. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| OP-08 - Different types of trips | O08-2 | The system shall promote the use of a data standard that describes real-time crowding information |
| OP-12 - Precise stop locations | O12-1 | The system shall promote the use of a data standard that supports precise stop location information. |
| OP-13 - Notify riders of delay | O13-1 | The system shall promote the use of a data standard that includes real-time service change information for demand-responsive trips. |
| RID-01-5 - DR delay | R01-5-1 | The system shall promote the use of a data standard that enables distribution of system alert information for demand responsive service including whether a specific rider's trip is being provided. |
| RID-18 - Safety features | R18-1 | The system shall the use of use a data standard that describes safety features and amenities available such as lights and shelters during and near a transit trip. |
| RID-18-1 - Safety at waiting area | R18-1-1 | The system shall promote the use of a data standard that describes transit stop amenities such as shelters, lights, or restrooms. |
| RID-19-3 - Loading mobility device | R19-3-1 | The system shall promote the use of a data standard that describes real-time vehicle capabilities including details of options for loading bicycles and wheelchair lift capabilities. |
| RID-22 - Veteran info | R22-1 | The system shall promote the use of a data standard that supports eligibility program information and eligibility verification requirements for riders who are veterans. |
| RID-29 - Info before arrival | R29-1 | The system shall promote the use of a data standard that describes details of wayfinding and vehicle information. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-34 - Elevators in service | R34-1 | The system shall promote the use of a data standard that describes real-time system alerts related to pathway accessibility, including at a minimum elevator outages and other barriers to mobility devices or limits to mobility-assistive infrastructure. |
| MUL-05 - Real-time vehicle auditing | M05-2 | The system shall promote the use of a data standard that allows for the real-time viewing of demand-responsive vehicle locations by authorized parties in a manner that accounts for the privacy concerns of demand-responsive riders. |
| OP-14 - Caregivers and other rider DR partners | O14-1 | The system shall promote the use of a data standard which users to book multiple passengers or indicate other passengers will be traveling with them. |
| OP-15 - Service animals | O15-1 | The system shall promote the use of a data standard that includes information on service animal rules for transit vehicles. |
| REG-02 - Anonymized DR trips | E03-1 | The system shall promote the use of a data standard that captures ridership data by stop, route, and agency. |
| REG-05 - Vehicle location auditing | E05-1 | The system shall promote the use of a data standard that describes vehicles and vehicle qualities (i.e.: GTFS-Vehicles). |
| REG-05 - Vehicle location auditing | E05-1.1 | The system shall promote the use of a data standard that includes the fields necessary to meet the FTA and NTD requirements for documenting assets. |
| RID-14-2 - Cost for party | R14-2-1 | The system shall promote the use a data standard that describes any fares associated with other members of their party. |
| RID-18-2 - Station patrol | R18-2-1 | The system shall promote the use a data standard that indicates security guard/officer presence at stops and stations. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-18-3 - Stops along route | R18-3-1 | The system shall include as part of published best practices that rider applications provide context for amenities that are available along a planned trip. |
| RID-18-4 - Safety at intermediate points | R18-4-1 | The system shall promote the use of a data standard that describes safety features and amenities available during a transit trip. |
| RID-18-5 - Restroom locations | R18-5-1 | The system shall promote the use of a data standard that describes public restrooms information at transit stops, including whether those restrooms are gendered, multi- or single-occupancy, accessible, and have baby-changing stations. |
| RID-19-5 - Bikes on board | R19-5-1 | The system shall promote the use of a data standard that supports describing the vehicle capacity to carry bikes onboard. |
| RID-19-6 - Bikes on board real-time | R19-6-1 | The system shall promote the use of a data standard that supports describing the real-time or predicted vehicle capacity to carry bikes onboard. |
| RID-19-7 - Mobility device charging | R19-7-1 | The system shall promote the use of a data standard that describes presence of outlets for mobility device charging or other purposes on vehicles. |
| RID-19-8 - Bike parking | R19-8-1 | The system shall promote the use of a data standard that describes bike parking information at transit stops. |
| RID-38 - Expect crowding | R38-1 | The system shall promote the use of a data standard that describes crowding of transit waiting zones. |
| RID-43 - Service animal | R43-1 | The system shall promote the use of a data standard that describes vehicle capabilities to support service animals during the demand-responsive booking process. |

## 2.2.2. ET #2: Mobility App Ecosystem (“Apps”)

***Description***

Mobility Apps are software applications with web and/or mobile applications that import GTFS data and provide information to riders about how to access transit services.

Like Transit Data Standards, Apps are important to but not directly governed by the proposed system. Unlike Transit Data Standards, these apps are typically owned and operated by a business, or an open source application operated by a software consultancy or other organization. Thus, the project can make suggestions about the use cases which should be considered by these apps but cannot direct vendors to develop any particular features within their apps. This section will overview the specific technologies that enable apps but not analyze them individually on account of being unable to directly affect the component technologies.

Enabling Technologies for the Mobility App Ecosystem:

- Internet service
- Personal computers
- Web apps
- Smartphones
- Native smartphone apps

***Procurement***

The following are particular vendors that provide the web apps and native smartphone apps which operate on personal computers and smartphones connected to internet service. This list is not exhaustive and the market changes consistently and new vendors will arise during the course of the system deployment.

- Google Maps
- Transit
- Navilens
- Moovit
- OpenTripPlanner
- OneBusAway

- CityMapper
- Apple Maps
- Lyft
- Uber

***Traceability***

As described above, Apps are not actually system components, but rather planned users of the system components. User Needs and System Requirements for these technologies is thus not part of the scope of this project.

### 2.2.3. ET #3: Scheduling and CAD/AVL systems

***Description***

Scheduling and CAD/AVL ("Computer Aided Dispatch and Automated Vehicle Location") systems are software applications and associated hardware that are used by transit agencies to manage their operations and provide rider information.

Like the Mobility App Ecosystem, these Scheduling and CAD/AVL systems will not be directly purchased by, developed, or otherwise managed by the proposed system. However, the Data and Procurement Guidelines will describe the features these systems should have and the data standards they should export. This section will overview the specific technologies that enable these systems but not analyze them individually on account of being unable to directly affect the component technologies.

List of Enabling Technologies for the Scheduling and CAD/AVL systems:

- Fixed-route scheduling applications
- Demand-responsive scheduling applications
- Fixed-route CAD/AVL software and hardware
- Demand-responsive CAD/AVL software and hardware
- Other hardware and software collecting and communicating data to be distributed through the Mobility App Ecosystem

***Procurement***

The following are particular vendors that provide the systems listed above to transit operators. This list is not exhaustive and the market changes consistently and new vendors will arise during the course of the system deployment.

- Hastus
- Optibus
- Trapeze
- Avail
- RideCo
- Shotl
- Liftango
- Routematch by Uber
- Transloc

***Traceability***

As described above, CAD/AVL and scheduling software application are not actually system components, but rather planned users of the system components. User Needs and System Requirements for these technologies is thus not part of the scope of this project.

### 2.2.4. ET #4.1 Database of Metadata about transportation datasets (Official List of Transportation Services)

***Description***

This is a machine-readable subset of data from data banks that describes the transportation services in the three-state region. This is a simple list of agency names, urls, and possibly a few other discrete data elements that are common to most transit systems and not already contained within GTFS data.

***Integration***

The primary purpose of this ET is to store and make available the data sources to be used to create the frontend directory.

***Procurement***

The database of metadata about transportation datasets will be off-the-shelf and ready to use as is, and will integrate with the system through a common database interface requiring minimum additional development. Vendors will provide both the database, along with the development work necessary to integrate into the system. The following are potential vendors:

- Transitland Atlas (Interline)

- Mobility Database (MobilityData)
- Trillium-maintained state transit data portals (e.g., oregon-gtfs.org)
- Any customized database management software, adapted by the internal development team

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 2: ET #4.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-03 - Contact information | M03-1 | The system shall consume operator contact information including a phone number, website, and email address. |
| REG-04 - Administrative contact | E04-1 | The system shall provide a public official list of service administrators and the services they oversee. |

### 2.2.5. ET #4.2 Metadata editing interface (Official List of Transportation Services)

***Description***

This is a platform that allows for data to be edited, added to, or deleted.

***Integration***

The primary role of the metadata editing interface is to allow authorized users to directly edit data in the database to ensure high quality, complete, and current information.

***Procurement***

The metadata editing interface will need to be modified from well-developed existing frameworks. Additionally, each of the products use different platforms for data editing, which should be a consideration when thinking about which is the most accessible to most transportation providers. The following are potential vendors:

- Transitland Atlas GitHub Repository (Interline)
- Mobility Database Wikibase instance (MobilityData)

- Manual file maintenance or other custom process

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 3: ET #4.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-03 - Contact information | M03-1 | The system shall consume operator contact information including a phone number, website, and email address. |

## 2.2.6. ET #5.1: Data Bank (Data APIs)

***Description***

The data bank is a software that allows the storage of copies of transportation datasets. The data bank will act as a repository for transportation information and will allow for remote retrieval of the data stored. The data bank is essentially a series of databases.

***Integration***

The data bank is necessary to know what data exists. There will be specific data extracted from these datasets. While these databases include much of the needed information, more needs to be added. The project needs to choose which database to use, especially one that can be relied on to be maintained long term.

***Procurement***

The data bank will be off-the-shelf and used as is. The following are potential vendors:

- Mobility Archives (MobilityData)
- Transitland Atlas (Interline)

Note: Regional DOTs maintain transit data quality and aggregate that data on an ongoing basis. However, the data is not complete. The project intends to improve completeness through agreed upon minimum data guidelines and most importantly by creating an open ecosystem that incentivizes transportation providers to share data. The Mobility Archive best serves this purpose as several GTFS-consuming applications are backing development of the product alongside The Mobility Database. The Mobility Archive is currently in private beta and is built within a proven out-

of-the-box cloud computing solution. However, pending the finalization of the software design of the API Endpoints (ET #5.2), the specific technology cannot be selected as the alternative may be more practical within certain design contexts.

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 4: ET #5.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-1 | The system shall include data on all operators (as defined by the SCC) including all routes, stops, service hours, and service times for those operators. |
| MUL-01 - See full network | M01-1.1 | The system shall consume transit data through automated collection of data in standardized formats, including all data standards promoted by the system. |
| MUL-03 - Contact information | M03-1 | The system shall consume operator contact information including a phone number, website, and email address. |
| OP-01 - Integrated trip planning | O01-1 | The system shall include direct download links for all operators' transit data. |
| B2G-01 - Identify customers | G01-1 | The system shall publish information regarding transportation operators including data about the size (e.g., number of routes, vehicles, stops) and modes provided by each service. |
| OP-12 - Precise stop locations | O12-2 | The system shall publish the latitude and longitude of every transit stop with a unique ID within the region. |
| REG-02 - Anonymized DR trips | E02-1 | The system shall capture historical realtime data for transit services in the deployment region and store in a secure location. |
| REG-04 - Administrative contact | E04-1 | The system shall provide a public official list of service administrators and the services they oversee. |

## 2.2.7. ET #5.2: API endpoints (Data APIs)

***Description***

The application programming interface (API) is a programming interface allowing for the automated retrieval of data for use in analysis and software. It acts as an intermediary to relay information from one software interface to another.

***Integration***

The main use of the API is to serve as a bridge between the data and the interface that is used to view the data. For this project, it needs to be a shared model that allows the DOTs appropriate licensing and hosting of the application and ability to transmit it to other state parties to allow evolution of the interface on a consistent basis.

***Procurement***

The API (for transit data) will need to be modified for this project. The following are potential vendors:

- Transitland Datastore API (Interline)
- Mobility Archives (MobilityData)
- The custom development of entirely new APIs is also a potential option, but not preferred

Transitland API is currently operational. Mobility Archives has planned the development of an API. The selection of the open source software to be modified for this technology during the software design process may constrain the practical options which can be selected for ET #5.1.

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 5: ET #5.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-1 | The system shall include data on all operators (as defined by the SCC) including all routes, stops, service hours, and service times for those operators. |
| MUL-01 - See full network | M01-1.2 | The system shall publish transit data through an API and a UI that can be navigated by a person familiar with common transit data standards, including all data standards promoted by the system. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-4 | The system shall include as part of the API endpoints the use of open and common standards for the format of those endpoints. |
| MUL-03 - Contact information | M03-2 | The system shall publish operator contact information including a phone number, website, and email address. |
| OP-01 - Integrated trip planning | O01-1 | The system shall include direct download links for all operators' transit data. |
| OP-01 - Integrated trip planning | O01-1.1 | The system shall include the ability of users to sign up for notifications when an operators' data is first published or existing data is updated. |
| OP-01 - Integrated trip planning | O01-1.2 | The system shall include the ability to download the newest or specific past versions of operator data sets at stable download links. |
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| B2G-01 - Identify customers | G01-1 | The system shall publish information regarding transportation operators including data about the size (e.g., number of routes, vehicles, stops) and modes provided by each service. |
| OP-12 - Precise stop locations | O12-2 | The system shall publish the latitude and longitude of every transit stop with a unique ID within the region. |
| B2G-02 - Assess quality | G02-1 | The system shall include as part of the API endpoints the integration of automated validator software that confirms the validity of the retrieved data. |
| REG-04 - Administrative contact | E04-1 | The system shall provide a public official list of service administrators and the services they oversee. |

## 2.2.8. ET #6.1: Data viewing interface (Directory/Analysis Frontend)

***Description***

This is a website presenting basic transit operator data in a visually digestible format to viewers using a computer or a browser on a mobile device.

***Integration***

The primary role of the data viewing interface is to allow data to be presented to users on an internet browser. Similar systems exist and are in operation although customization will be required and the development of a new open source application is likely the most practical option.

***Procurement***

This technology is ready to be used but will need to be modified for this project. The following are potential vendors:

- Transit.land website/MobilityExplorer (Interline)
- OpenMobilityData v2 website (MobilityData)
- Juniper website (Compiler LA/Caltrans)
- ODOT Transit Network Explorer Tool (TNexT)
- CA Mobility Marketplace provider map (Caltrans)

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 6: ET #6.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-1 | The system shall include data on all operators (as defined by the SCC) including all routes, stops, service hours, and service times for those operators. |
| MUL-01 - See full network | M01-1.2 | The system shall publish transit data through an API and a UI that can be navigated by a person familiar with common transit data standards, including all data standards promoted by the system. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-2 | The system shall include as part of a data viewing interface both list and map views of data. |
| MUL-01 - See full network | M01-2.1 | The system shall include as part of a data viewing interface the ability to search operators by route, stop, or service area through the map view. |
| MUL-01 - See full network | M01-2.2 | The system shall include as part of a data viewing interface the ability to filter operators by route, stop, or service area through the map view. |
| MUL-01 - See full network | M01-2.3 | The system shall include as part of a data viewing interface the ability to search operators by route, stop, or service area through the list view. |
| MUL-01 - See full network | M01-2.4 | The system shall include as part of a data viewing interface the ability to filter operators by route, stop, or service area through the list view. |
| MUL-01 - See full network | M01-3 | The system shall include as part of a data viewing interface a responsive site design. |
| MUL-03 - Contact information | M03-1 | The system shall consume operator contact information including a phone number, website, and email address. |
| MUL-03 - Contact information | M03-2 | The system shall publish operator contact information including a phone number, website, and email address. |
| OP-01 - Integrated trip planning | O01-1 | The system shall include direct download links for all operators' transit data. |
| OP-01 - Integrated trip planning | O01-1.1 | The system shall include the ability of users to sign up for notifications when an operators' data is first published or existing data is updated. |
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-20-1 - Preferred language | R20-1-1 | The system shall provide interfaces which are internationalized (i18n) to support the loading of translations in any language. |
| | R20-3-1 | The system shall provide interfaces that are designed inclusively to meet state and federal ADA guidelines for supporting users with hearing disabilities. |
| B2G-01 - Identify customers | G01-1 | The system shall publish information regarding transportation operators including data about the size (e.g., number of routes, vehicles, stops) and modes provided by each service. |
| OP-12 - Precise stop locations | O12-2 | The system shall publish the latitude and longitude of every transit stop with a unique ID within the region. |
| REG-04 - Administrative contact | E04-1 | The system shall provide a public official list of service administrators and the services they oversee. |

### 2.2.9. ET #6.2 Data analysis interface (Directory/Analysis Frontend)

***Description***

This is an interface that allows for the retrieval of reports and data sets needed for further analysis processes that take place outside of the system.

***Integration***

The primary role of the data analysis interface is to enable the download of customizable data for planning purposes and other analysis. All GTFS entities should be downloadable in customizable ways for local analysis, as well as custom reports to fit specific use cases and user needs.

***Procurement***

The data analysis interface will need to be modified for this project. The following are potential vendors:

- ODOT Transit Network Explorer Tool (TNexT)

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 7: ET #6.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-1 | The system shall include data on all operators (as defined by the SCC) including all routes, stops, service hours, and service times for those operators. |
| OP-01 - Integrated trip planning | O01-1 | The system shall include direct download links for all operators' transit data. |
| OP-01 - Integrated trip planning | O01-1.2 | The system shall include the ability to download the newest or specific past versions of operator data sets at stable download links. |
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |
| RID-20-1 - Preferred language | R20-1-1 | The system shall provide interfaces which are internationalized (i18n) to support the loading of translations in any language. |
| RID-20-1 - Preferred language | R20-3-1 | The system shall provide interfaces that are designed inclusively to meet state and federal ADA guidelines for supporting users with hearing disabilities. |
| B2G-01 - Identify customers | G01-1 | The system shall publish information regarding transportation operators including data about the size (e.g., number of routes, vehicles, stops) and modes provided by each service. |
| OP-12 - Precise stop locations | O12-2 | The system shall publish the latitude and longitude of every transit stop with a unique ID within the region. |
| REG-01 - Assess compliance | E01-1 | The system shall support the automating the assessment of compliance with minimum data guidelines where feasible, as defined by the System Coordination Committee. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| REG-04 - Administrative contact | E04-1 | The system shall provide a public official list of service administrators and the services they oversee. |

## 2.2.10. ET #7.1: Knowledge Base Software (Knowledge Base/1st Tier Support Desk)

***Description***

This is a customer service software that will allow riders to ask questions about the transit service via an online portal. Riders will be able to ask questions about things such as the right contacts for transit information in their region and assistance in using shared tools like the directory/analysis frontend or commercial mobile applications.

***Integration***

The primary role of the knowledge base software is to allow users to efficiently retrieve information they need about the service that they are unable to access on the directory website, or to access that information through a more conversational method. Products for this technology which are provided on the market are built to easily integrate into other websites and platforms through their APIs.

***Procurement***

The technology is off-the-shelf and ready to use as is. The following are potential vendors:

- Zendesk
- Slite
- HelpJuice
- Atlassian
- HelpCrunch
- Document360
- Hubspot service

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 8: ET #7.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-03 - Contact information | M03-2 | The system shall publish operator contact information including a phone number, website, and email address. |
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |
| RID-13 - App guidance | R13-2 | The system shall provide a single consolidated backend system (i.e. support desk) available through multiple channels (e.g. web, SMS, phone) across the deployment area for riders needing customer service support to planning trips. |
| RID-13 - App guidance | R13-2.1 | The system shall include as part of the support desk documentation for customer service staff to assist riders when they are learning to use trip planning systems. |
| RID-15 - Customer service | R15-1 | The system shall provide a general customer service support desk operated by a human to answer riders' transit questions which can be answered by reference to information within the operator's public GTFS and GTFS Realtime |
| RID-20-2 - Plain language | R20-2-1 | The system shall include as part of published best practices that operators regularly to evaluate existing website, application, and marketing copy to determine whether it needs to exist or be rewritten for clarity and conciseness. |
| | R20-3-3 | The system shall include as part of the support desk either live chat, messaging, or TDD feature for riders who cannot otherwise access auditory phone services. |
| RID-44 - Operator feedback | R44-1 | The system shall include as part of the support desk a customer feedback portal where a rider can submit comments which are then provided to the operator. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-44 - Operator feedback | R44-2 | The system shall include as part of the support desk the tracking of instances feedback to ensure routing to the right operator and confirmation of an issue resolution. |

## 2.2.11. ET #7.2: Support issue ticketing and resolution software (Knowledge Base/1st Tier Support Desk)

***Description***

This is a customer service software that allows riders to email or text regarding trip planning, booking, cancelling, or modifying a trip. It also allows the support desk to respond to issues and ensure they have been resolved.

***Integration***

The primary role of this enabling technology is to allow riders the ability to access instant online and mobile assistance for ticketing issues.

***Procurement***

The technology is off-the-shelf and ready to use as is. The following are potential vendors:

- Zendesk
- Freshdesk
- Intercom

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 9: ET #7.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-04 - Hear text annunciation | R04-3 | The system shall include as part of published best practices that riders be provided tools to communicate feedback to data producers to improve Text-to-Speech quality. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |
| RID-13 - App guidance | R13-2 | The system shall provide a single consolidated backend system (i.e. support desk) available through multiple channels (e.g. web, SMS, phone) across the deployment area for riders needing customer service support to planning trips. |
| RID-13 - App guidance | R13-2.1 | The system shall include as part of the support desk documentation for customer service staff to assist riders when they are learning to use trip planning systems. |
| RID-13 - App guidance | R13-2.2 | The system shall include as part of the support desk a feature to track all customer service interactions using a ticketing system (i.e.: method of communication, date of communication, issue, how issue resolved). |
| RID-15 - Customer service | R15-1 | The system shall provide a general customer service support desk operated by a human to answer riders' transit questions which can be answered by reference to information within the operator's public GTFS and GTFS Realtime |
| RID-15 - Customer service | R15-2 | The system shall include as part of the support desk an auditory mode of communication for its customer service functions. |
| RID-15 - Customer service | R15-3 | The system shall include as part of the support desk text-based mode of communication for its customer service functions. |
| | R20-3-3 | The system shall include as part of the support desk either live chat, messaging, or TDD feature for riders who cannot otherwise access auditory phone services. |
| RID-44 - Operator feedback | R44-1 | The system shall include as part of the support desk a customer feedback portal where a rider can submit comments which are then provided to the operator. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-44 - Operator feedback | R44-2 | The system shall include as part of the support desk the tracking of instances feedback to ensure routing to the right operator and confirmation of an issue resolution. |

## 2.2.12. ET #7.3: Call center (Knowledge Base/1st Tier Support Desk)

***Description***

This is an in-office system that allows riders to call in and ask questions related to transit services, as well as book, cancel, or modify their trip.

***Integration***

The primary role of this technology is to allow riders who do not have access to a computer or smartphone to ask questions about and utilize the system.

***Procurement***

The technology is ready to integrate into the system as is. Potential vendors include:

- Anveo
- RingCentral
- Contract labor approaches

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 10: ET #7.3 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-13 - App guidance | R13-2 | The system shall provide a single consolidated backend system (i.e. support desk) available through multiple channels (e.g. web, SMS, phone) across the deployment area for riders needing customer service support to planning trips. |
| RID-15 - Customer service | R15-1 | The system shall provide a general customer service support desk operated by a human to answer riders' transit questions which can be answered by reference to information within the operator's public GTFS and GTFS Realtime |
| RID-15 - Customer service | R15-2 | The system shall include as part of the support desk an auditory mode of communication for its customer service functions. |
| RID-17 - No internet | R17-2 | The system shall provide a customer service channels that do not require internet connectivity for riders to ask general questions related to transit options in the deployment area. |

## 2.2.13. ET #8.1: Accessibility Guidelines (Interface Feature Wishlist)

***Description***

Web Content Accessibility Guidelines (WCAG) define how to make web content more accessible to people with disabilities.

***Integration***

These guidelines will be used to ensure that accessibility requirements are being met.

***Procurement***

The current version of WCAG 2.2 was issued on Nov. 30, 2020, and the WCAG 2 Series is coming to an end with a new WCAG 3.0 under development. WCAG 3.0 will not undo the previous versions, but will extend and provide greater clarity concerning current guidelines. The following are possible vendors:

- Web Content Accessibility Guidelines (WCAG 2.1 or newer current version)

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 11: ET #8.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-02 - Clear governance | M02-2.4 | The system shall include as part of the System Coordination Committee the incorporation of feedback from the underserved communities identified by this project. |
| MUL-03 - Contact information | M03-3 | The system shall provide best practices for which contacts at an agency should be included in public contact information and suggested service levels for those contact channels. |
| OP-02 - Booking through rider apps | O02-1 | The system shall promote the use of a data standard that allows users to book demand responsive trips through third party trip planning applications. |
| OP-02 - Booking through rider apps | O02-1.1 | The system shall promote the use of a data standard that allows users to book demand responsive trips through a third party application by deeplinking to a different application for the final booking confirmation. |
| OP-02 - Booking through rider apps | O02-1.1 | The system shall promote the use of a data standard that allows users to book demand responsive trips entirely within a third party application through the use of APIs. |
| OP-03 - Tech sophistication not required | O03-1.3 | The system shall include as part of published best practices examples of high-quality transit data that operators can use as a model. |
| RID-01-3 - DR travel time | R01-3-3 | The system shall include as part of published best practices that consuming applications provide feedback from riders to operators in order to improve the estimation of travel time on an ongoing basis. |
| RID-01-4 - DR wait time | R01-4-3 | The system shall include as part of published best practices that consuming applications provide feedback from riders to operators in order to improve the estimation of wait time on an ongoing basis. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-02 - Various trips | R02-1 | The system shall include as part of published best practices for trip planning applications that include the need to provide users with multiple trip options when multiple options are possible. |
| RID-02 - Various trips | R02-2 | The system shall include as part of published best practices for trip planning applications that include the need to avoid showing users trips for which they are not eligible or which are not otherwise relevant to them. |
| RID-04 - Hear text annunciation | R04-2 | The system shall include as part of published best practices guidance for application developers which publish and consume Text-to-Speech data to support the needs of users who rely on audio annunciation. |
| RID-04 - Hear text annunciation | R04-3 | The system shall include as part of published best practices that riders be provided tools to communicate feedback to data producers to improve Text-to-Speech quality. |
| RID-14 - Cost of service | R14-2 | The system shall include as part of published best practices that trip planning applications include information about fares, including passes, fare-caps, discounted or subsidized fares, and temporary price reductions. |
| RID-14-1 - Standard payment media | R14-1-2 | The system shall include as part of published best practices how transit apps can describe payment media, and may need to describe how to integrate mobile-based payment media directly into user interfaces. |
| RID-14-1 - Standard payment media | R14-1-3 | The system shall provide as budget allows interagency technical coordination to facilitate adoption of payment systems which improve rider ease of use. |
| RID-19 - Device accessible | R19-1 | The system shall promote the use of a data standard that describes vehicle capabilities (capabilities to support wheelchair, bike, or other mobility devices). |
| RID-19-1 - Space for mobility device | R19-1-1 | The system shall promote the use of a data standard or align with emerging data standards that describes real-time vehicle capabilities (capabilities to support wheelchair, bike, or other mobility devices). |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-19-2 - Pathways in advance | R19-2-3 | The system shall include as part of published best practice that trip planning applications include information on pathways using the GTFS-Pathways data specification (https://gtfs.org/reference/static/#pathwaystxt). |
| RID-20-1 - Preferred language | R20-1-3 | The system shall include as part of published best practices that trip planning applications are internationalized and provide support for translations in multiple languages. |
| RID-20-2 - Plain language | R20-2-1 | The system shall include as part of published best practices that operators regularly to evaluate existing website, application, and marketing copy to determine whether it needs to exist or be rewritten for clarity and conciseness. |
| RID-20-2 - Plain language | R20-2-2 | The system shall include as part of published best practices guidance for transit user interface design that all language used be at a fifth grade reading level. |
| | R20-3-2 | The system shall include as part of published best practices guidance regarding inclusive design for supporting users with hearing disabilities. |
| B2C-01 - Connection with customer | C01-1 | The system shall include as part of published best practices that rider applications include a user feedback function. |
| B2C-02 - Accessibility guidance | C02-1 | The system shall include as part of published best practices references to educational resources for WCAG 3.0 compliance targeted at rider application vendors. |
| OP-06 - Serve requests precisely | O06-1 | The system shall promote the use of a data standard that allows operators to set restrictions on the trips offered to ensure compliant and efficient trips. |
| RID-13-1 - No experience necessary | R13-1-1 | The system shall publish best practices for trip planning applications that include the need to design accessible, intuitive interfaces. |
| RID-17-1 - Real-time through SMS | R17-1-1 | The system shall include as part of published best practices the that operators provide real-time trip information via text message. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-17-2 - Limited internet | R17-1-2 | The system shall include as part of published best practices that trip planning applications offer offline support for riders planning trips. |
| RID-19-4 - Space for mobility device real-time | R19-4-1 | The system shall include as part of published best practices that trip planning applications enable riders to see when the next trip would be if they don't take the trip being viewed. |
| RID-20 - Diversity of interfaces | R20-1 | The system shall include as part of published best practices that operators allow multiple applications consume their data and serve their riders. |
| RID-21 - Talk to app | R21-1 | The system shall include as part of published best practices for rider applications provide riders the ability to use the app with verbal commands. |
| RID-23 - Present location | R23-1 | The system shall include as part of published best practices that operators publish real-time vehicle locations in a standardized data format. |
| RID-24 - Various notifications | R24-1 | The system shall include as part of published best practices that rider applications allow users to customize trip notification recipients and include multiple recipients. |
| RID-25 - Safety feature hours | R25-1 | The system shall include as part of published best practices that rider applications display map features such as businesses, buildings, services and landmarks nearby stop locations. |
| RID-26 - Know about TDD | R26-1 | The system shall include as part of published best practices that agencies and rider applications notify users that accessibility features, including TDD, are available when such features are present. |
| RID-27 - Confidence in info | R27-1 | The system shall provide data quality assurance processes to ensure GTFS data and other data standards promoted by the system are maintained at the level of quality defined by the System Coordination Committee. |
| RID-28 - Limit words | R28-1 | The system shall include as part of published best practices that commercial trip planning applications design simple interfaces that allow a user to find the most important information quickly. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-30 - Consistent experience | R30-1 | The system shall include as part of published best practices that operators and rider applications implement new interfaces and interface features in a fashion that does not require intensive application re-training frequently. |
| RID-31 - Adjust preferences | R31-1 | The system shall include as part of published best practices that rider applications allow users to indicate feature preferences for possible trips. |
| RID-32 - Exact stop locations | R32-2 | The system shall include as part of published best practices that rider applications display and announce when possible the current user location relative to the boarding an alighting locations. |
| MUL-07 - Map data | M07-2 | The system shall include within published best practices a list of acceptable geocoders for mapping features in the right-of-way. |
| OP-14 - Caregivers and other rider DR partners | O14-2 | The system shall include as part of published best practices that rider applications allow users to book multiple passengers or indicate other passengers will be traveling with them. |
| OP-16 - Communicate pathway quality | O16-1 | The system shall include as part of published best practices that rider applications provide information regarding the expected quality of pathways data used within the application. |
| RID-01-6 - DR origin and destination | R01-6-1 | The system shall include as part of published best practices that trip planning applications include a confirmation that the correct origin and destination has been acknowledged by a demand responsive service. |
| RID-01-7 - Book quickly | R01-7-1 | The system shall include as part of published best practices that booking and brokerage systems minimize wait times for trip confirmations. |
| RID-19-9 - Trust pathway validation | R19-9-1 | The system shall include as part of published best practices ways for communicating data quality of pathways information to users. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-35 - Right stop | R35-1 | The system shall include as part of published best practices that rider applications include the need to provide confirmation of user location relative to transit stops through text and audio as well as visual format. |
| RID-36 - Way back home | R36-1 | The system shall include as part of published best practices that rider applications provide trip notifications for the absence of return journeys. |
| RID-37 - Various options | R37-1 | The system shall include as part of published best practices that rider applications provide diverse and distinct options when the user does indicate preferences to restrict those options. |
| RID-42 - Navigation directions | R42-1 | The system shall include as part of published best practices the need to word trip directions in a way that does not solely depend on cardinal directionality. |
| RID-45 - Communicate without text | R45-1 | The system shall include as part of published best practices recommendations and useful resources for communicating with riders with limited written English proficiency. |

## 2.2.14. ET #8.2: Documentation website (Interface Feature Wishlist)

***Description***

This is a method of keeping track of desired application features that are not fulfilled by rider-facing transit apps today and will not be initially developed for the project.

***Integration***

Many stakeholder interviews identified desired application features that are not fulfilled by rider-facing transit apps today. This project does not intend to design customer interfaces but may recommend that some user interface features be provided by app developers and revisit and update those recommendations as the project progresses.

***Procurement***

The following are possible vendors:

- WordPress

- Drupal
- Other content management system

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 12: ET #8.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |
| RID-14-1 - Standard payment media | R14-1-3 | The system shall provide as budget allows interagency technical coordination to facilitate adoption of payment systems which improve rider ease of use. |
| RID-20-1 - Preferred language | R20-1-1 | The system shall provide interfaces which are internationalized (i18n) to support the loading of translations in any language. |
| | R20-3-1 | The system shall provide interfaces that are designed inclusively to meet state and federal ADA guidelines for supporting users with hearing disabilities. |
| RID-27 - Confidence in info | R27-1 | The system shall provide data quality assurance processes to ensure GTFS data and other data standards promoted by the system are maintained at the level of quality defined by the System Coordination Committee. |
| MUL-07 - Map data | M07-2 | The system shall include within published best practices a list of acceptable geocoders for mapping features in the right-of-way. |

## 2.2.15. ET #9.1: Minimum Data Guidelines (Data and Procurement Guidelines)

***Description***

These are the specific requirements to publish and maintain certain data utilizing certain data standards.

***Integration***

The data and procurement guidelines would be defined with a phased implementation and accompanying support to ensure that each agency in the state is able to easily comply and to ensure the results of updated data are apparent in commercial rider applications. Requirements will be inserted into funding agreements with transit operators.

***Procurement***

The following are potential vendors:

- California Minimum GTFS Guidelines
- Mobility Data Interoperability Principles
- Custom development of new guidelines

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 13: ET #9.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-1 | The system shall include data on all operators (as defined by the SCC) including all routes, stops, service hours, and service times for those operators. |
| MUL-02 - Clear governance | M02-1 | The system shall promote the use of data standards that align with the Mobility Interoperability Principles (link), such as GTFS and GTFS Realtime. |
| MUL-03 - Contact information | M03-3 | The system shall provide best practices for which contacts at an agency should be included in public contact information and suggested service levels for those contact channels. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-03 - Contact information | M03-3.1 | The system shall provide suggestions of what staff or functional contacts should be included, based on different agency characteristics (such as size of agency, type of organization). |
| MUL-03 - Contact information | M03-3.2 | The system shall provide suggestions of how quickly certain types of communications should be responded to. |
| MUL-03 - Contact information | M03-4 | The system shall promote the use of a data standard to describe operator contact information, including phone numbers, websites, and email addresses for different operator functionalities. |
| OP-02 - Booking through rider apps | O02-1 | The system shall promote the use of a data standard that allows users to book demand responsive trips through third party trip planning applications. |
| OP-02 - Booking through rider apps | O02-1.1 | The system shall promote the use of a data standard that allows users to book demand responsive trips through a third party application by deeplinking to a different application for the final booking confirmation. |
| OP-02 - Booking through rider apps | O02-1.1 | The system shall promote the use of a data standard that allows users to book demand responsive trips entirely within a third party application through the use of APIs. |
| OP-02-1 - Time of booking | O02-1-1 | The system shall promote the use of a data standard that allows operators to define allowed booking times for demand-responsive services. |
| OP-03 - Tech sophistication not required | O03-1 | The system shall provide best practices that data be published by agencies according to a standard of quality that can be assessed without dependence on agency technical capacity. |
| OP-03 - Tech sophistication not required | O03-1.1 | The system shall include as part of published best practices data quality guidelines including standards of data completeness and effectiveness for rider needs which extend beyond the whether data is valid. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| OP-03 - Tech sophistication not required | O03-1.2 | The system shall include as part of published best practices educational resources for operators or links to educational resources on how to successfully produce or procure high-quality data. |
| OP-03 - Tech sophistication not required | O03-1.3 | The system shall include as part of published best practices examples of high-quality transit data that operators can use as a model. |
| OP-03 - Tech sophistication not required | O03-1.4 | The system shall include as part of published best practices references to validation tools which can be used to determine the quality of a data set in an automated fashion. |
| RID-01 - Discover DR | R01-1 | The system shall promote the use of a data standard that describes available demand-responsive trips for discovery in trip planning applications. |
| RID-01-3 - DR travel time | R01-3-1 | The system shall promote the use of a data standard that supports modeling of expected travel time for demand-responsive trips. (i.e.: mean_duration_factor in GTFS-flex specification) |
| RID-01-3 - DR travel time | R01-3-2 | The system shall include as part of published best practices that operators publish data which allows a consuming application to calculate estimated travel time for demand-responsive trips. |
| RID-01-4 - DR wait time | R01-4-1 | The system shall promote the use of a data standard that supports modeling of expected wait time prior to the beginning of the trip for demand-responsive trips. |
| RID-01-4 - DR wait time | R01-4-2 | The system shall include as part of published best practices that operators publish data which allows a consuming application to calculate estimated wait time for demand-responsive trips. |
| RID-03 - Eligibility process | R03-1 | The system shall promote the use of a data standard that supports eligibility program information and eligibility verification requirements for transit services. |
| RID-04 - Hear text annunciation | R04-1 | The system shall promote the use of a data standard that supports including Text-to-Speech information to facilitate improved audio annunciation by data consuming systems. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-04 - Hear text annunciation | R04-2 | The system shall include as part of published best practices guidance for application developers which publish and consume Text-to-Speech data to support the needs of users who rely on audio annunciation. |
| RID-04 - Hear text annunciation | R04-3 | The system shall include as part of published best practices that riders be provided tools to communicate feedback to data producers to improve Text-to-Speech quality. |
| RID-04-1 - Audio option | R04-1-1 | The system shall promote the use of a data standard that describes alert, wayfinding, or service regulation information. |
| RID-14 - Cost of service | R14-1 | The system shall promote the use of a data standard that describes fares including passes, fare-caps, discounted or subsidized fares, and temporary price reductions. |
| RID-14-1 - Standard payment media | R14-1-4 | The system shall include as part of published best practices that agencies maintain an option to allow payment at time of boarding without a smartphone even if payment in advance by app is enabled. |
| RID-19-2 - Pathways in advance | R19-2-1 | The system shall promote the use of the GTFS-Pathways data specification (https://gtfs.org/reference/static/#pathwaystxt). |
| | R20-1-2 | The system shall promote the use of the GTFS-Translations specification (http://gtfs.org/reference/static/#translationstxt). |
| RID-20-1 - Preferred language | R20-1-3 | The system shall include as part of published best practices that operators use the GTFS-Translations extension to provide translations of GTFS elements for all languages they are required to support by state and federal guidelines. |
| RID-20-2 - Plain language | R20-2-1 | The system shall include as part of published best practices that operators regularly to evaluate existing website, application, and marketing copy to determine whether it needs to exist or be rewritten for clarity and conciseness. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| OP-10 - Assess data quality | O10-1 | The system shall present data publication requirements, and related resources, in an easily accessible format available to all operators. |
| OP-12 - Precise stop locations | O12-1 | The system shall promote the use of a data standard that supports precise stop location information. |
| RID-01-5 - DR delay | R01-5-1 | The system shall promote the use of a data standard that enables distribution of system alert information for demand responsive service including whether a specific rider's trip is being provided. |
| RID-16 - Communicate with driver | R16-1 | The system shall include as part of published best practices identification of the need to provide riders with multiple options for communicating with a driver. |
| RID-17-1 - Real-time through SMS | R17-1-1 | The system shall include as part of published best practices the that operators provide real-time trip information via text message. |
| RID-17-2 - Limited internet | R17-1-2 | The system shall include as part of published best practices that trip planning applications offer offline support for riders planning trips. |
| RID-18 - Safety features | R18-1 | The system shall the use of use a data standard that describes safety features and amenities available such as lights and shelters during and near a transit trip. |
| RID-18-1 - Safety at waiting area | R18-1-1 | The system shall promote the use of a data standard that describes transit stop amenities such as shelters, lights, or restrooms. |
| RID-30 - Consistent experience | R30-1 | The system shall include as part of published best practices that operators and rider applications implement new interfaces and interface features in a fashion that does not require intensive application re-training frequently. |
| RID-32 - Exact stop locations | R32-1 | The system shall include as part of published best practices that transit agencies meet a level of stop location and service area precision and accuracy that allows riders to plan and make trips with confidence in their boarding and alighting locations |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-34 - Elevators in service | R34-1 | The system shall promote the use of a data standard that describes real-time system alerts related to pathway accessibility, including at a minimum elevator outages and other barriers to mobility devices or limits to mobility-assistive infrastructure. |
| MUL-05 - Real-time vehicle auditing | M05-1 | The system shall include as part of published best practices that agencies provide real-time vehicle location feeds for fixed-route services. |
| MUL-05 - Real-time vehicle auditing | M05-2 | The system shall promote the use of a data standard that allows for the real-time viewing of demand-responsive vehicle locations by authorized parties in a manner that accounts for the privacy concerns of demand-responsive riders. |
| MUL-07 - Map data | M07-1 | The system promotes the use of a data standard to map features in the right of way. |
| MUL-07 - Map data | M07-2 | The system shall include within published best practices a list of acceptable geocoders for mapping features in the right-of-way. |
| OP-14 - Caregivers and other rider DR partners | O14-1 | The system shall promote the use of a data standard which users to book multiple passengers or indicate other passengers will be traveling with them. |
| OP-15 - Service animals | O15-1 | The system shall promote the use of a data standard that includes information on service animal rules for transit vehicles. |
| REG-02 - Anonymized DR trips | E02-2 | The system shall include as part of published best practices methodologies for the anonymization and aggregation of demand-responsive trips for planning and policy decision-making |
| REG-02 - Anonymized DR trips | E03-1 | The system shall promote the use of a data standard that captures ridership data by stop, route, and agency. |
| REG-04 - Administrative contact | E04-2 | The system shall include as part of published best practices definitions of terms like "service", "operator", "administrator" etc. that allow for the clear description of different types of administrative contacts. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| REG-05 - Vehicle location auditing | E05-1 | The system shall promote the use of a data standard that describes vehicles and vehicle qualities (i.e.: GTFS-Vehicles). |
| REG-05 - Vehicle location auditing | E05-1.1 | The system shall promote the use of a data standard that includes the fields necessary to meet the FTA and NTD requirements for documenting assets. |
| RID-01-7 - Book quickly | R01-7-1 | The system shall include as part of published best practices that booking and brokerage systems minimize wait times for trip confirmations. |
| RID-14-2 - Cost for party | R14-2-1 | The system shall promote the use a data standard that describes any fares associated with other members of their party. |
| RID-16-1 - Communicate without voice | R16-1-1 | The system shall include as part of published best practices that agencies provide options to riders to communicate with drivers using non-verbal methods. |
| RID-18-2 - Station patrol | R18-2-1 | The system shall promote the use a data standard that indicates security guard/officer presence at stops and stations. |
| RID-18-3 - Stops along route | R18-3-1 | The system shall include as part of published best practices that rider applications provide context for amenities that are available along a planned trip. |
| RID-18-4 - Safety at intermediate points | R18-4-1 | The system shall promote the use of a data standard that describes safety features and amenities available during a transit trip. |
| RID-18-5 - Restroom locations | R18-5-1 | The system shall promote the use of a data standard that describes public restrooms information at transit stops, including whether those restrooms are gendered, multi- or single-occupancy, accessible, and have baby-changing stations. |
| RID-19-5 - Bikes on board | R19-5-1 | The system shall promote the use of a data standard that supports describing the vehicle capacity to carry bikes onboard. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-19-6 - Bikes on board real-time | R19-6-1 | The system shall promote the use of a data standard that supports describing the real-time or predicted vehicle capacity to carry bikes onboard. |
| RID-19-7 - Mobility device charging | R19-7-1 | The system shall promote the use of a data standard that describes presence of outlets for mobility device charging or other purposes on vehicles. |
| RID-19-8 - Bike parking | R19-8-1 | The system shall promote the use of a data standard that describes bike parking information at transit stops. |
| RID-19-9 - Trust pathway validation | R19-9-1 | The system shall include as part of published best practices ways for communicating data quality of pathways information to users. |
| RID-38 - Expect crowding | R38-1 | The system shall promote the use of a data standard that describes crowding of transit waiting zones. |
| RID-43 - Service animal | R43-1 | The system shall promote the use of a data standard that describes vehicle capabilities to support service animals during the demand-responsive booking process. |

### 2.2.16. ET #9.2: Documentation website (Data and Procurement Guidelines)

***Description***
This is the method of keeping track and publishing data and procurement guidelines.

***Integration***
The primary role of this ET is to ensure that changes to guidelines are tracked over time and disseminated to all relevant parties. It is a custom website that houses the guidelines and can be reviewed by new Mobility App Ecosystem vendors or tracked by current vendors for changes.

***Procurement***
The following are potential vendors:

- WordPress
- Drupal
- Other website content management system

***Traceability***
Below are the user needs and system requirements expected to be met through this technology.

**Table 14: ET #9.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-01 - See full network | M01-1 | The system shall include data on all operators (as defined by the SCC) including all routes, stops, service hours, and service times for those operators. |
| OP-01 - Integrated trip planning | O01-1 | The system shall include direct download links for all operators' transit data. |
| OP-01 - Integrated trip planning | O01-1.2 | The system shall include the ability to download the newest or specific past versions of operator data sets at stable download links. |
| RID-04-1 - Audio option | R04-4 | The system shall provide interfaces which are compliant with federal and state accessibility guidelines (i.e.: alert text accessible to external screen reader tools). |
| RID-13 - App guidance | R13-1 | The system shall provide interfaces which follow user interface and user interaction design best practices. |
| RID-20-1 - Preferred language | R20-1-1 | The system shall provide interfaces which are internationalized (i18n) to support the loading of translations in any language. |
| | R20-3-1 | The system shall provide interfaces that are designed inclusively to meet state and federal ADA guidelines for supporting users with hearing disabilities. |
| B2G-01 - Identify customers | G01-1 | The system shall publish information regarding transportation operators including data about the size (e.g., number of routes, vehicles, stops) and modes provided by each service. |
| OP-12 - Precise stop locations | O12-2 | The system shall publish the latitude and longitude of every transit stop with a unique ID within the region. |
| REG-01 - Assess compliance | E01-1 | The system shall support the automating the assessment of compliance with minimum data guidelines where feasible, as defined by the System Coordination Committee. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| REG-04 - Administrative contact | E04-1 | The system shall provide a public official list of service administrators and the services they oversee. |

## 2.2.17. ET #10.1: Interstate Partnership Document (System Coordination Committee + Accessibility, Payment, Eligibility, and Wayfinding Coordination Teams)

***Description***

This is the formal documentation between agencies regarding roles and deliverables for the project.

***Integration***

The primary role of the interstate partnership documentation is to ensure all involved agencies understand what is expected of them.

***Procurement***

This technology must be developed by the project. There are models to work off of, but no vendors from which the technology can be procured.

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 15: ET #10.1 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-02 - Clear governance | M02-1 | The system shall promote the use of data standards that align with the Mobility Interoperability Principles (link), such as GTFS and GTFS Realtime. |
| MUL-02 - Clear governance | M02-2.1 | The system shall include as part of the System Coordination Committee governance processes which are brief and documented openly. |

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| RID-14-1 - Standard payment media | R14-1-3 | The system shall provide as budget allows interagency technical coordination to facilitate adoption of payment systems which improve rider ease of use. |

## 2.2.18. ET #10.2: Communications Platform (System Coordination Committee + Accessibility, Payment, Eligibility, and Wayfinding Coordination Teams)

***Description***

This is a product management and collaboration software that will be used to share information about the project.

***Integration***

The primary role of the communications platform is to facilitate ongoing and efficient coordination to share stories, troubleshoot, upvote, etc. It will be used by the System Coordination Committee and the Accessibility, Mapping, Payment, Eligibility, Wayfinding Coordination teams.

***Procurement***

The technology will be off-the-shelf and used as is. The following are potential vendors:

- Basecamp
- GitHub
- Product Board
- Airtable
- Product Plan

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 16: ET #10.2 traceability to system requirements and user needs**

| User Need ID | Requirement ID | Requirement Description |
|---|---|---|
| MUL-02 - Clear governance | M02-2.2 | The system shall provide resources that explain other related governance processes (such as the GTFS changes process). |
| MUL-02 - Clear governance | M02-2.3 | The system shall include as part of the System Coordination Committee the incorporation of feedback from active contributors to open transit data specifications. |
| MUL-02 - Clear governance | M02-2.4 | The system shall include as part of the System Coordination Committee the incorporation of feedback from the underserved communities identified by this project. |
| RID-14-1 - Standard payment media | R14-1-3 | The system shall provide as budget allows interagency technical coordination to facilitate adoption of payment systems which improve rider ease of use. |

## 2.2.19. ET #11.1: APIs (Brokerage Software)

***Description***

This is a software that allows different transit providers to be pooled and respond to different trips, e.g., a non-ADA user could utilize a paratransit system.

***Integration***

The primary role of this technology is to allow for better coordination between neighboring agencies for rides. If implemented, the brokerage software would be built or deployed in partnership with but operated, maintained, and governed by transit operators locally. This would allow operators to benefit from open data specifications and shared development without encroaching on local agency operations. Currently, data models exist to exchange information between demand-responsive agencies via brokerages and could fulfil the use case. However, it would not be necessary for the other components of the system to fulfill their requirements.

***Procurement***

This technology would need to be built for the system. A brokerage could be a standalone feature governed through a different model than other system subcomponents. The following are potential vendors:

- FlexRide (Demandtrans/Kyyti)

- Ecolane

***Traceability***

Below are the user needs and system requirements expected to be met through this technology.

**Table 17: ET #11.1 traceability to system requirements and user needs**

| Need ID | New Req ID | Requirement Description |
|---|---|---|
| RID-14-1 - Standard payment media | R14-1-3 | The system shall provide as budget allows interagency technical coordination to facilitate adoption of payment systems which improve rider ease of use. |
| RID-19 - Device accessible | R19-1 | The system shall promote the use of a data standard that describes vehicle capabilities (capabilities to support wheelchair, bike, or other mobility devices). |
| RID-19-1 - Space for mobility device | R19-1-1 | The system shall promote the use of a data standard or align with emerging data standards that describes real-time vehicle capabilities (capabilities to support wheelchair, bike, or other mobility devices). |
| RID-20-1 - Preferred language | R20-1-1 | The system shall provide interfaces which are internationalized (i18n) to support the loading of translations in any language. |
| | R20-1-2 | The system shall promote the use of the GTFS-Translations specification (http://gtfs.org/reference/static/#translationstxt). |
| RID-20-2 - Plain language | R20-2-1 | The system shall include as part of published best practices that operators regularly to evaluate existing website, application, and marketing copy to determine whether it needs to exist or be rewritten for clarity and conciseness. |
| | R20-3-1 | The system shall provide interfaces that are designed inclusively to meet state and federal ADA guidelines for supporting users with hearing disabilities. |
| OP-06 - Serve requests precisely | O06-1 | The system shall promote the use of a data standard that allows operators to set restrictions on the trips offered to ensure compliant and efficient trips. |
| OP-14 - Caregivers and other rider DR partners | O14-1 | The system shall promote the use of a data standard which users to book multiple passengers or indicate other passengers will be traveling with them. |
| OP-14 - Caregivers and other rider DR partners | O14-2 | The system shall include as part of published best practices that rider applications allow users to book multiple passengers or indicate other passengers will be traveling with them. |

| Need ID | New Req ID | Requirement Description |
|---|---|---|
| RID-01-7 - Book quickly | R01-7-1 | The system shall include as part of published best practices that booking and brokerage systems minimize wait times for trip confirmations. |

# 3. Technology Readiness Level (TRL)

This section provides the Technology Readiness Level for each ET listed in Section 2 of this document. The TRL is a formal process that supports the assessment of technologies and provides the ability to compare the levels of maturities among different technologies.

## 3.1. TRL Assessment Process

The Technology Readiness Framework based on the ISO Standard 16290 Space systems by NASA was used for the TRL assessment process. The following questions were asked to consistently assess the TRL of each enabling technology:

1. How mature is this technology?
2. Is it widely adopted and available?
3. How much modification does it need to work within the proposed system?

TRL levels were assessed through market research and investigative interviews of technical partners by the task team and collaborative discussion within the task team, led by MobilityData and reviewed by the System Development Lead. TRL levels were initially defined by MobilityData and finalized by the System Development Lead. MobilityData used SimilarWeb—a website traffic analytic tool—to analyze the usage of various software products and identify similar tools. Interviews were held with regulatory, GTFS data producing, and GTFS data consuming technical partners to identify technology options and fit to identified use cases. Final TRL values were determined by consensus of the task team members after internal discussion. These TRL values will be reconsidered after the completion of the System Requirement Specification report, and during the course of Phases 2 and 3 when development and deployment is proceeding. The partners interviewed were Transit, Trillium, NaviLens, Accessible Avenue, Oregon Department of Transportation (ODOT), and The California Integrated Travel Project (Cal-ITP).

The primary potential bias related to the identification of vendors in the previous section and assessment of technology readiness in the present section is the authorship of this report by MobilityData, when some of the technologies assessed in this report include MobilityData as a potential vendor. This has been considered as a source of bias but is accepted and ignored for the following reasons. MobilityData is a non-profit organization with a clear scope and open governance process. The technologies identified existed on MobilityData's roadmap or were already offered prior to the ITS4US project, and additional technology vendors other than MobilityData have been identified. MobilityData will not be involved in the selection of appropriate technology vendors, and will be subject to the same evaluation process as other vendors. Finally, MobilityData is a named partner of the project and is instrumental to the system approach, being the currently identified technical non-profit in the proposed system diagram, for which no other competitor currently exists; it is the intention to further include MobilityData within system development, so part of the purpose of this report is to identify the areas within which their participation is required, or where other industry actors should be considered.

# 3.2. TRL Ratings for Inventoried Enabling Technologies

This section provides corresponding information that supports the TRL chosen for each enabling technology.

### 3.2.1. ET #1: Transit Data Standards
### 3.2.2. GTFS-Schedule - TRL 9

GTFS-Schedule is currently in widespread use.

### 3.2.3. GTFS-Fares - TRL 6

While GTFS-Fares is currently in widespread use, many concepts required for this project have not yet been implemented and proven. The following features of GTFS-Fares are being utilized:

- The implementation of GTFS-Fares by T Fare costs for individual legs of travel
- Fares for routes and networks of routes
- Fares for area location groups
- Detailed transfer rules between legs of travel

### 3.2.4. GTFS-Eligibilities - TRL 3

GTFS-Eligibilities is drafted, but not yet in use.

### 3.2.5. GTFS-Realtime - TRL 9

GTFS-Realtime is currently in widespread use.

### 3.2.6. GTFS-TextToSpeech - TRL 8

GTFS-TextToSpeech is currently in limited use. Current use cases from TriMet include:

- Abbreviation are spelled out long: e.g. “SW” vs “southwest”
- Strange pronunciation are described: e.g. “Orenco” pronounced like “orrainkoe”

- Big digit are read in the vernacular way: e.g. “3300” is said “thirty-three-hundred”

### 3.2.7. GTFS-Pathways - TRL 8

GTFS-Pathways is currently in limited use. Current users include Metropolitan Transportation Commission in partnership with Interline, Transit app, and Google.

### 3.2.8. GTFS-Vehicles - TRL 3

GTFS-Vehicles is drafted, but not yet in use.

### 3.2.9. GTFS-Capabilities - TRL 3

GTFS-Capabilities is currently drafted, but not yet in use.

### 3.2.10. GOFS - TRL 7

GOFS (including GTFS-Flex) is currently in use, but in beta and under development.

### 3.2.11. ET #2: Mobility App Ecosystem (“Apps”) – TRL 8

Mobility apps already exist and are commonly used by riders. However, the purpose of this project is to encourage further changes to these applications to support identified user needs.

### 3.2.12. ET #3: Scheduling and CAD/AVL systems – TRL 8

Scheduling and CAD/AVL systems already exist and are commonly used by operators. However, the purpose of this project is to encourage further changes to these applications to support identified user needs.

### 3.2.13. ET #4.1 Database of Metadata about transportation datasets (Official List of Transportation Services) – TRL 9

This technology is off the shelf and ready to be used as is.

### 3.2.14. ET #4.2 Metadata editing interface (Official List of Transportation Services) – TRL 7

This technology is ready to be used, but will need to be modified for this project. Shared identifiers and other specific fields may need to be added to make this technology ready for this project. The technology platform in use allows for the addition of additional concepts, governance will require coordination.

### 3.2.15. ET #5.1: Data Bank (Data APIs) – TRL 7

Databanks are widely adopted and utilized technologies and have been proven in an operational environment, but the specific requirements of the data bank for this project requires specialized features relevant to storing and loading transit data elements efficiently. Two maturing products are available, however, substantial customizations will be necessary to integrate this technology successfully.

### 3.2.16. ET #5.2: API endpoints (Data APIs) – TRL 6

This component is complete, however, significant modifications will need to be made to accommodate additional concepts including demand responsive service for this project.

### 3.2.17. ET #6.1: Data viewing interface (Directory/Analysis Frontend) – TRL 7

This technology is ready to be used, but will need to be modified for this project.

### 3.2.18. ET #6.2 Data analysis interface (Directory/Analysis Frontend) – TRL 7

This technology is ready to be used, but will need to be modified for this project. Some vendors offer data viewing interfaces with robust features but require governance updates, others would require software updates to meet the additional use from the project.

### 3.2.19. ET #7.1: Knowledge Base Software (Knowledge Base/1st Tier Support Desk) – TRL 9

This technology is off-the-shelf and ready to be used as is.

### 3.2.20. ET #7.2: Support issue ticketing and resolution software (Knowledge Base/1st Tier Support Desk) – TRL 8

This technology is ready to be used, but will need some modification.

### 3.2.21. ET #7.3: Call center (Knowledge Base/1st Tier Support Desk) – TRL 9

This technology is off-the-shelf and ready to be used as is.

### 3.2.22. ET #8.1: Accessibility Guidelines (Interface Feature Wishlist) – TRL 8

This technology is ready to be used though requires customization and additional context for publication within this project.

### 3.2.23. ET #8.2: Documentation website (Interface Feature Wishlist) – TRL 9

This technology is mature and in use.

### 3.2.24. ET #9.1: Minimum Data Guidelines (Data and Procurement Guidelines) – TRL 7

This technology is in use by Caltrans but will need some additional modification to work on a broader scale and to include additional standardization use cases.

### 3.2.25. ET #9.2: Documentation website (Data and Procurement Guidelines) – TRL 9

This technology is ready to be used as is.

### 3.2.26. ET #10.1: Interstate Partnership Document (System Coordination Committee + Accessibility, Payment, Eligibility, and Wayfinding Coordination Teams) – TRL 5

This technology is in use but needs modification to work between DOTs regarding technology governance issues.

### 3.2.27. ET #10.2: Communications Platform (System Coordination Committee + Accessibility, Payment, Eligibility, and Wayfinding Coordination Teams) – TRL 9

This technology is mature and in widespread use. It is ready to be used as is.

### 3.2.28. ET #11.1: APIs (Brokerage Software) – TRL 4

This technology is in use in some applications that do not rely on open data standards. Extensive development and customization will be needed to support use for this project.

# 4. Risk Assessment

This section describes and discusses all known and anticipated risks that may affect the deployment. For each ET, known and potential risks are itemized below.

## 4.1. Assessing Risk

The risk assessment was performed by interviewing several project partners. The purpose of the project is to meet the user needs we identified through interviews and other means, so we defined impact as how significantly users would be impacted if the risk described occurred:

- low = very few users would be impacted in a minor way
- medium = some users would be impacted, but not in a significant way
- high = many users would be impacted in a significant way

**Table 18. Risk Assessment for Each Enabling Technology**

| Risk ID | Enabling Technology | Risk Description | Impact Level |
|---|---|---|---|
| 1.a. | Data Standards | Some data standards required for the project are still under development and need to be finalized, including GTFS-Fares, GTFS-Eligibilities, GTFS-Vehicles, and GTFS-Flex & GOFS. | High |
| 2.a. | Internet service | If the mobility app cannot access the internet, riders won't have real-time information. | Medium |
| 2.b. | Personal computers | No known risk to our project. | no risk |
| 2.c. | Web apps | No known risk to our project. | no risk |
| 2.d. | Smartphones | Some riders do not have smartphones, and our app(s) may not work on older or low-quality smartphones. | Low |
| 2.e. | Native smartphone apps | For-profit transportation apps may have a conflict of interest in that their revenue is derived from advertising services that aren't the best choice for the user, e.g., showing a taxi ride, but not a bus ride. | Medium |

| Risk ID | Enabling Technology | Risk Description | Impact Level |
|---|---|---|---|
| 2.f. | Native smartphone apps | For-profit transportation app developers may not be interested in providing an app in a market that is too small to be profitable. | High |
| 2.g. | Native smartphone apps | Potential riders may not know about the app(s) (discoverability) and why they would benefit from using an app. | High |
| 2.h. | Native smartphone apps | The design (interface) and experience, i.e., a "buggy" app, could be poor, or riders could simply not understand how to use them. | High |
| 2.i. | Native smartphone apps | The design (interface) could not be accessible to riders with disabilities or riders with limited English proficiency. | Low |
| 2.j. | Native smartphone apps | There may be security vulnerabilities. | Low |
| 2.k. | Native smartphone apps | GPS can compromise rider privacy. | Low |
| 2.l. | Native smartphone apps | The app may not be kept up to date. | Low |
| 2.m. | Native smartphone apps | The new information (e.g., accessibility) that the project intends to provide and services (such as deep links to payment and booking) may not be included in the app. | High |
| 2.n. | Native smartphone apps | Support for certain needed features implemented through the project may be dropped later. | High |
| 2.o. | Native smartphone apps | Because GPS can't accurately show the last few feet of wayfinding (e.g., tall buildings can block GPS, GPS doesn't work in subways or inside buildings), the app may not provide the specificity of location needed for some riders. | High |
| 3.a | Scheduling and CAD/AVL systems | There may be security vulnerabilities. | Low |
| 3.b | Scheduling and CAD/AVL systems | For-profit *software* developers may not be interested in providing an app in a market that is too small to be profitable*, such as to rural or certain demand response agencies* | Medium |
| 3.c | Demand responsive scheduling software | Schedule information with driver or passenger information can compromise user privacy. | Medium |

| Risk ID | Enabling Technology | Risk Description | Impact Level |
|---|---|---|---|
| 4.1.a. | Database of metadata about transportation datasets | There is a potential for gaps in the data or incorrect data, e.g., a phone number no longer works. | Medium |
| 4.2.a. | Metadata editing interface | An individual or a bot could compromise the data. | High |
| 5.1.a. | Databank | The data could be compromised, e.g., 1) someone could access a databank and compromise it through a download, 2) a URL could be broken, or 3) a gap in GTFS data could delegitimize the source of truth. | High |
| 5.1.b | Databank | The project could invest in a code base that ceases to be maintained and utilized by other parties. | High |
| 5.2.a. | API (for transit data) | If software is developed for the project by an outside vendor, that vendor could lose interest or go out of business. If software is developed for the project by an agency, or consortium of agencies, they could lose interest or lose funding. | High |
| 6.1.a. | Data viewing interface | The website could be designed in a way that does not fully meet the primary end users' needs. | Medium |
| 6.1.b. | Data viewing interface | The website could be designed in a way that doesn't meet accessibility standards, such as not being compatible with screen readers. | High |
| 6.2.a. | Data analysis interface | No known risk to our project. | no risk |
| 7.1.a. | Knowledge base software | Privacy could be compromised if questions entered contain personal information. | Low |
| 7.2.a. | Support issue ticketing & resolution software | Privacy could be compromised if personal data is entered into support tickets. | Low |
| 7.2.b. | Support issue ticketing & resolution software | The ticketing system could be too complicated for customers. | Medium |
| 7.3.a. | Call center | It may not be possible for a call center to cover a three-state area. | Medium |
| 7.3.b. | Call center | A call center is expensive, with the cost of technicians as opposed to a fully-automated system potentially jeopardizing the ability to provide a call center long-term. | Medium |

| Risk ID | Enabling Technology | Risk Description | Impact Level |
|---|---|---|---|
| 7.3.c. | Call center | The customer service could be poor and/or backlogged and with call center representatives providing inconsistent information and not using the right type of messaging for the agency they are representing. | Medium |
| 8.1.a. | Accessibility guidelines for interface feature wishlist | Accessibility guidelines may not be correctly implemented in the various system interfaces. | High |
| 8.2.a. | Documentation website for interface feature wishlist | Desired features and best practices may be abandoned and new ones may not be included. | Low |
| 9.1.a. | Minimum data guidelines | The project needs consistent, reliable data that can easily be retrieved and that is maintained over time. Despite many data standards being in place, publication of GTFS data by transportation providers is not universal, often due to lack of familiarity with technology or lack of resources to implement the technology, which can result in disorganized and incomplete datasets. Likewise, inconsistent implementation of optional fields may result in an inconsistent user experience, especially with cross-agency travel planning and within the context of the "complete trip." The wider the deployment area, the more difficult it might be to guarantee a certain quality of service. | Medium |
| 9.2.a. | Documentation website for data & procurement guidelines | No known risk to our project. | no risk |
| 10.1.a. | Interstate partnership documentation | No known risk to our project. | no risk |
| 10.2.a. | Communications platform(s) for committees and teams | No known risk to our project. | no risk |
| 11.1.a. | API (for brokerage, booking, payment, settlement) | Data from different vendors may vary widely (no standardization) and may be difficult to combine. | Medium |

## 4.2. Mitigating Risk

The likelihood of each of the risks rated “high-impact” in the evaluation above is identified below, along with a mitigation plan associated with the risk.

**Table 19. High-Impact Risk Mitigation Plans**

| Risk ID | Risk Probability | Mitigation Plan |
|---|---|---|
| 1.a. | Low | Although certain data standards are still under development, we are confident that the standards needed to ensure a positive trip for people with disabilities and other disadvantaged riders will be ready, and we will develop GTFS implementation manuals standardizing nomenclatures and how to incorporate data into GTFS files to help data producers incorporate the new standards. |
| 4.2.a. | Medium | To mitigate the potential that data in the databank for the data repository could be compromised, we will create a centralized system that is highly available and meets all security standards to ensure that the databank is always available and to guarantee data integrity. |
| 5.1.a. | Low | To mitigate the issues associated with who develops and maintains the transit data API (a private vendor or public agency or consortium of agencies), we are considering developing the APIs collaboratively and maintaining software knowledge internally to the project to ensure they are not dependent on a vendor or on external funding. |
| 5.1.b | Medium | This risk can be partially mitigated by promoting in outreach materials the value of the partnership chosen in collaboration with any existing open source code-base. However, with the risk impact is high because the loss of an open source community would greatly reduce the scalability of the platform, it would not present a breaking issue for the operation of the system. Further, the returns on investment from extensive outreach promoting a partnership would be very low. Thus, while this risk will be partialy mitigated it will also be partially accepted and ignored. |
| 5.2.a. | Low | To mitigate the possibility that a bot or individual could compromise the metadata editing interface, we expect contributors who are technically aware of typical data contexts to recognize and block them. |
| 6.1.b. | Low | To mitigate the possibility that the data viewing interface (website) could be designed in a way that doesn't meet accessibility standards, we will include accessibility guidelines in procurement policies and accessibility tests in product development. |

| Risk ID | Risk Probability | Mitigation Plan |
|---|---|---|
| 2.f. | Medium | To mitigate the possibility that for-profit app developers may not find our market a profitable market for a native smartphone app because it is too small, we will standardize the data and make it widely available so that the area in which the app would operate will be considered profitable to the app developer. |
| 2.g. | Medium | To mitigate the possibility that potential riders may not discover or understand the benefit of a native smartphone app, we will increase marketing of transit availability generally and of app(s) serving the market specifically. |
| 2.h. | Low | To mitigate the possibility that the native smartphone app will be poorly designed, or buggy, or difficult to use, we will promulgate standards at the outset to ensure user-loved apps with great design are the ones involved. |
| 2.m. | Medium | To mitigate the possibility that the native smartphone app may not provide the information and services this project is focused on, we will standardize the data, and assist transportation providers in providing it so that it is easily accessible and usable by data consumers. |
| 2.n. | Low | To mitigate the possibility that support for features important to the project may be dropped from the native smartphone app, we will do outreach to the categories of disadvantaged riders this project intends to serve so that the app is well-utilized and the vendor sees the value. |
| 2.o. | Medium | Because wayfinding is important to the project, we will mitigate GPS issues by incorporating deep links into systems that can provide the exact location, such as QR code systems and/or beacon systems. |
| 8.12.a. | Low | To mitigate the possibility that accessibility guidelines aren't correctly implemented, we will make tools for validation of accessibility standards available to developers. |

# Appendix A. Acronyms and Glossary

Accessibility – Accessibility is used in this document to indicate the ability all riders—especially people with disabilities, Limited English Proficiency, or who faces other barriers to access transit—to use transit and transit technologies in a way that best supports those users' individual experiences with transit. A service or technology may be "accessible" as defined by the ADA, but may also present "accessibility barriers" which this project seeks to help riders manage, in order to make the service or technology "more accessible".

ADA - Americans with Disabilities Act

API - Application Programming Interface

B2C - Business to consumer

B2G - Business to government

BAA - Broad Agency Announcement

CA - State of California

CA PATH - California Partners for Advanced Transit and Highways

CAD/AVL – Computer-Aided Dispatch/Automatic Vehicle Location

CALACT - California Association for Coordinated Transportation

Caltrans - California Department of Transportation

CCPA - California Consumer Protection Act

CDL - Concept Development Lead

ConOps - Concept of Operations

Deep link – a deep link is a link within a mobile application which directs the user to another mobile application, rather than to a website.

Demand-responsive transit – Transit services which provide trips at a location and/or time that is requested by a rider. Generally, any transit service that is not Fixed-route is considered a type of Demand-responsive transit for the purposes of this document, including general public DAR, ADA paratransit, and other transit models.

DOT - Department of Transportation

Fixed-route transit – Transit services that provide service to the general public through vehicles which stop at designated locations (stops and stations) at designated times.

GPS – Global Positioning System

GTFS - General Transit Feed Specification

IEEE - Institute of Electrical and Electronics Engineers

IRB - Institutional Review Board

NEMT – Non-Emergency Medical Transportation

NIST 800-53 - National Institute of Standards and Technology

PII – Personally Identifiable Information

PLC - Project Leadership Committee

PML - Project Management Lead

PMO - Project Management Organization

PMP - Project Management Plan

PMT - Project Management Team

ODOT - Oregon Department of Transportation

OR - State of Oregon

OS - Operating System

SCC - System Coordination Committee

SDL - System Development Lead

SEMP - Systems Engineering Management Plan

SyRS - System Requirements Specification Document

TBD - To Be Determined

TTS – Text-to-Speech

TNC - Transportation Network Company

UI - User Interface

WA - State of Washington

WBS - Work Breakdown Structure

WSDOT - Washington State Department of Transportation

WSTA - Washington State Transportation Association

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