

Phase 1 System Requirements Specification (SyRS)

University of Washington ITS4US
Deployment Project

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16. Abstract <p>This document discusses the System Requirements Specification (SyRS) for the University of Washington (UW) ITS4US Deployment Project, which is developing and deploying the Transportation Data Equity Initiative (TDEI). This project currently is in Phase 1, planning and systems engineering development, in which the preliminary idea is developed into a structured concept that is suitable for further design, building, testing, and operation. The structured concept will include identifying specific performance measures, targets, and capabilities associated with performance monitoring and performance management.</p> <p>The SyRS is informed by the project's Concept of Operations (ConOps), Data Management Plan (DMP), Safety Management Plan (SMP), and Performance Measurement and Evaluation Support Plan (PMESP). The ConOps describes how the project will operate, as well as how those operations both meet the needs that motivated the project and the specific technical requirements from which the project is built. The DMP describes how data being collected for the project will be stored and shared, while maintaining the privacy of individuals participating in the project. The SMP describes potential hazards that users of the deployed system might encounter and how the project will keep those users as safe as possible, while the PMESP describes the key topics that need to be evaluated, as well as the sources of the data that are needed to perform those evaluations. These documents inform the SyRS, in that they generate requirements for system verification.</p> <p>This document is intended to be a living document. While preliminary system requirements are identified herein, many of the details regarding system capabilities, conditions, constraints, and interfaces will be worked out as part of development in Phase 2. It is anticipated that some requirements may be adjusted.</p>			
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1. Introduction

This document presents the System Requirements Specification (SyRS) for the University of Washington (UW) ITS4US Deployment Project, The Transportation Data Equity Initiative (TDEI), which is being performed as part of the U.S. Department of Transportation's (USDOT) Complete Trip—ITS4US Deployment Program. This deployment project aims to develop and deploy integrated, replicable, and scalable data pipelines to serve a consistent, shared data resource for downstream mobility solutions to functionalize complete trips for all travelers. Its vision is to deploy innovative and integrated complete trip systems to support seamless travel for users across all modes, regardless of location, income, or disability.

1.1. System Purpose

The SyRS follows the development of the Concept of Operations (ConOps) in the Systems Engineering process, as outlined in the Systems Engineering V-Model shown in **Figure 1**. As stated in the Federal Highway Administration's (FHWA) *Systems Engineering Guidebook for Intelligent Transportation Systems*,¹ system requirements define what the system is to do through statements defining system capabilities, conditions, and constraints. Requirements do not state how the system will be implemented unless it is intended to constraint the development team to a specific solution. These statements include guidelines necessary to confirm whether the project has been completed in accordance with the user needs from the ConOps from which the statements are based on. The SyRS are used as the basis for system acceptance in the System Verification Plan to confirm that all system requirements have been met (or not met, for well-defined reasons) and validate that the system is built as originally envisioned.

¹ FHWA California Division, Systems Engineering Guidebook for Intelligent Transportation Systems Version 3.0. November 2009. Available at: <https://www.fhwa.dot.gov/cadiv/segb/files/segbversion3.pdf>.

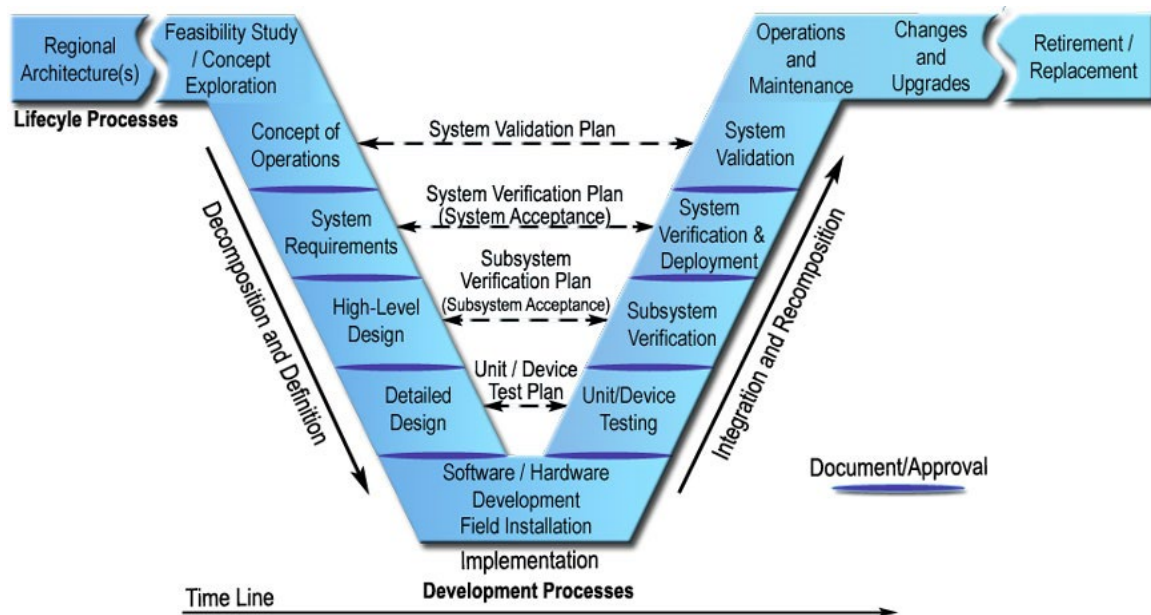


Figure 1. Diagram. Systems Engineering V-Model.

Source: Federal Highway Administration.

This document presents the system requirements for the UW ITS4US Deployment Project. Requirements are subdivided among different topic areas covering system capabilities, conditions, and constraints, as well as system interfaces. System capabilities conditions and constraints include functional system, physical, system performance characteristics, system security and privacy, information management, system operations, policy and regulation, and system lifecycle sustainment requirements. Each requirement is assigned a unique identifier, a clearly specified statement to serve as a requirement, a recommended verification method, and a priority level. All requirements are traceable to one or more user needs that were developed as part of the ConOps effort, signifying that these requirements are relevant to the goals and objectives of the proposed project. The traceability matrix is shown in **Appendix B**.

1.2. System Scope

Described in detail in the ConOps, the UW ITS4US Deployment Project aims to create the foundational data tools necessary for both public and private entities to collect, share, manage, and use transportation data that provide equitable outcomes to all travelers. At its core, the project is about creating the foundational requirements for interoperable transportation data sharing that fulfills the informational needs of all travelers. This requires a specific focus on the unmet needs of people with mobility disabilities and other historically travel-disadvantaged communities that are the focus of this project. Without implementing this type of project, the needs of these communities will continue to remain unmet or underserved, limiting the ability of citizens in these communities to access destinations, explore opportunities, and be aware of all services available to them.

The project itself consists of multiple parts:

- First, it includes work with three existing standards committees to extend and update existing, early-stage international data standards: OpenSidewalks, GTFS-Flex, and GTFS-Pathways. These three data standards enable the consistent collection and reporting of data that provide the underlying information needed by the currently underserved target populations—people with disabilities, older adults, and individuals with low income—to efficiently travel.
- The second part of the project is to develop a series of tools that help agencies, jurisdictions, and other stakeholders collect the data that can be stored with these refined data standards. These tools are needed to lower the cost and improve the quality and consistency of those data collection efforts to increase the availability of the data.
- The third portion of the project is to develop tools, policies, and procedures that allow sharing and governance of the collected data. The tasks performed will enable effective and efficient vetting, aggregation, management, and fusion of the data that participating agencies, jurisdictions, and other stakeholders collect. This portion of the project also includes tasks required to enable and manage the sharing of those data with application developers that write software to deliver requested travel information.
- The fourth portion of this project is the development of a data repository to contain the data to be shared within the six counties that represent the geographic boundaries for this ITS4US project. The data repository will be developed to illustrate how these data can be collected, stored, governed, updated, and maintained over time; and then served upon request to application developers.
- Finally, the fifth portion of this project is the development of three example applications that use the collected data. The three applications are intended to demonstrate three very different uses of the data that are collected, maintained, and made available to application developers as a result of the other four aspects of this project. Those data can be used to fulfill a variety of information needs, and those needs can be met through an almost infinite number of applications. The three applications deployed as part of this project are meant to show other application developers how the newly available data can be obtained and delivered.

Figure 2 illustrates the overall “new mobility” ecosystem to which the UW’s ITS4US project is contributing. The outer circle consists of a variety of public transportation services that exist. Many of these services already generate data that can be readily obtained by applications via Internet connections—the act which results in the discovery of “new mobility” options. These include fixed-route transit services, micro-mobility services, and taxi services. The UW ITS4US project will help add the data sources that are particularly important to people with mobility disabilities shown in purple at the bottom of the image. These are data that describe pedestrian pathways, transit station infrastructure, on-demand paratransit and community transit services, and other on-demand shared ride modes. The UW ITS4US project also is building the interoperable integrated transportation data-sharing layer and application program interface (API) shown in the green inner circle. This is the functionality needed to collect, fuse, and aggregate the data from disparate transportation services. Finally, the UWITS4US project will demonstrate a small number of applications used by the travelers shown in the center of the diagram. The applications take requests for information from the travelers; extract the required data from the data sharing layer (green circle); perform any required tasks—such as computing navigation

directions; and deliver information to users in formats (audio, text, tactile displays) designed to meet their needs.

Problem:

All travelers need usable information they can trust.

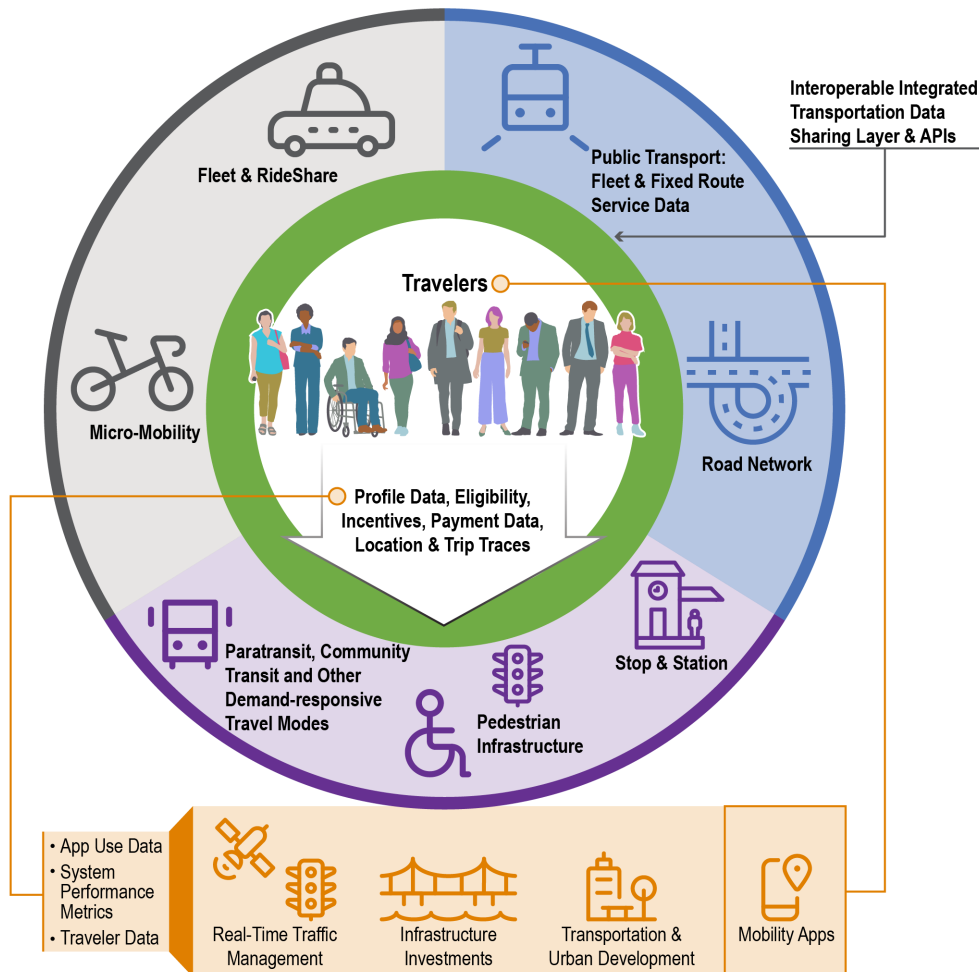


Figure 2. Diagram. University of Washington ITS4US project's ecosystem.

Source: University of Washington.

The UW Team has categorized the factors that motivated and shaped the development of this project into the following three categories:

1. Transportation and mobility are undergoing transformational changes that take advantage of data.
2. Accessible and inclusive design in data systems cannot be retrofitted without great cost/complexity.
3. Civic technology must be integrally driven by equitable, interoperable data-sharing infrastructure.

Further detail on these topic areas can be found in the ConOps.²

1.3. References

The following is a list of supporting documents used in the development of the SyRS.

- Caspi, Anat, et al., Phase 1 ConOps, UW ITS4US Deployment Project, Final Report—June 28, 2021, Report Number FHWA-JPO-21-861.
- Caspi, Anat, et al., Phase 1 Data Management Plan (DMP), UW ITS4US Deployment Project, Final Report—August 23, 2021, Report Number FHWA-JPO-21-869.
- Caspi, Anat, et al., Phase 1 Safety Management Plan (SMP), UW ITS4US Deployment Project, Final Report—August 23, 2021, Report Number FHWA-JPO-21-874.
- Caspi, Anat, et al., Phase 1 Performance Measurement and Evaluation Support Plan (PMESP), UW ITS4US Deployment Project, Draft Report—September 8, 2021, Report Number FHWA-JPO-21-879.
- FHWA, Systems Engineering Guidebook for Intelligent Transportation Systems, Version 3.0, November 2009.

1.4. System Overview

The UW ITS4US Deployment Project will achieve USDOT ITS4US Program goals by deploying the following key technology elements:

- **Develop a Centralized Data Repository**—The UW Team will develop a centralized data repository that services many functions. It receives, validates, and quality assures incoming sidewalk and transit-related data that are provided by data generators and transit agencies. It then stores the latest versions of data in the data repository for use. It also accommodates data requests made through an API service from applications that request geographically focused data to satisfy trip making. This component represents the focal point of the project for moving data from those who produce it to those who want to use it.
- **Create tools to support data collection**—The UW Team will develop tools for sidewalk infrastructure owner-operators and transit agencies to collect data, translate it into the preferred data standard, and submit data to the data repository. The goal of this component is to simplify the level-of-effort required to collect this data, thus, encouraging agencies to undertake this data collection initiative.
- **Demonstrate use of the data by under-represented communities through three accessibility-focused mobility applications.** This project will deploy accessible mobility applications in the evaluation and testing of the usability and efficacy of the data standards and the supporting infrastructure. The mobility applications will include:

² The UW ITS4US Deployment Project Phase 1 Concept of Operations report can be found on <https://www.its.dot.gov/its4us/index.htm>.

- A comprehensive, multimodal, personalized routing and trip planning Web and mobile application addressing the needs of people with mobility limitations, particularly supporting travel and exploration through new environments. The ConOps initially identified Multimodal AccessMap as a potential demonstration application for serving this population.
- A specialized orientation and exploration mobility iPhone Operating System (iOS) application enabling blind, vision disabled, or deafblind travelers to perform spontaneous travel and explore new pedestrian environments without having to specify a destination. The ConOps initially identified Microsoft Soundscape as a potential demonstration application for serving this population.
- A simulation tool that allows travelers (specifically sighted older adults and multilingual, multicultural travelers) to explore and visualize a trip path through a transit station that they need to use prior to taking a trip.

The system requirements that are outlined in this document discuss the necessary elements to validate that the system aligns with the proposed concept outlined in the ConOps and is traceable to the User Needs introduced in the ConOps document.

2. General System Description

This section provides a high-level overview of the proposed TDEI system, including context diagrams; system modes and states; major system capabilities; major system conditions, constraints, assumptions, and dependencies; user characteristics; and operational scenarios. Additional details can be found in the ConOps.

2.1. System Context

The proposed system will greatly increase the availability of pedestrian pathway data and flexible transit information to all travelers, build sustainable data infrastructure that enables widespread availability for data contributors and application developers, and utilize data standards to help efficiently structure the data needs. In order to accomplish these objectives, the proposed system will rely on several technological services, hereafter referred to in this document as *subsystems*, to facilitate the various subtasks that address specific user needs. These services will be organized into a general architecture, described in the Phase I Enabling Technologies document, which allows the overall system to function while accomplishing sub elements necessary to complete system tasks.

At a high level, a successful system (and all associated task-oriented services) requires the following: 1) a means to collect data; 2) a means to vet, update, and further process the data; and 3) a means to distribute those data to targeted user groups. Various subsystems that serve a role to the proposed system are allocated among these three steps.



Source: University of Washington and Cambridge Systematics.

This proposed system will operate in this framework with varying levels of effort and/or development among the three functions outlined in **Table 1**.

Table 1. Summary of the data service components of the proposed system.

Function	Description	Subsystem Components of the Proposed System
Data Collection	These components involve data sets and/or data flows that extract information on the pedestrian-built environment (e.g., sidewalks, pedestrian pathways, etc.); transit station facilities; and transit services (on-demand or fixed route) from other data sources.	<ul style="list-style-type: none"> • Massive data service providers using TDEI microservices for extraction of sidewalk, transit, or transportation facility information from their own imagery (satellite or street side), and/or light detection and ranging (LiDAR) datasets. • Mapping Technology Company Sidewalk Data Producer Subsystem. • Infrastructure Owner-Operator Sidewalk Data Producer Subsystem. • Crowdsourced Sidewalk Data Aggregator Subsystem. • Transportation Service Data Contributor Subsystem.
Information Processing	These components comprehensively receive, validate, and store data in the data repository to be used in travel planning.	<ul style="list-style-type: none"> • Sidewalks Data Processing Subsystem. • General Transit Feed Specification (GTFS) Data Processing Subsystem.
Information Distribution	These components distribute relevant data sets from the data repository for the accessible mobility environment upon request. These components also collect data from the processing components, convert those data into their own applications, and offer their own service to end users with specific preferences.	<ul style="list-style-type: none"> • OpenSidewalks Service Subsystem. • GTFS Service Subsystem. • Wayfinding Application Subsystem. • Auditory Orientation Subsystem. • Environment Simulation Subsystem. • Third-Party Application Subsystem.
Other Supporting Systems	These components involve data flows that offer other data relevant to multimodal travel choices (e.g., meteorological weather data).	<ul style="list-style-type: none"> • External Data Services. • Service Monitoring. • Service Registration. • Identity and Authentication Services.

Source: University of Washington and Cambridge Systematics.

Many service components make up the overall proposed system; and most are owned, operated, and maintained by different stakeholders. Many components reside in their own respective subsystem and are provided their own operating environment; often under the ownership of their

respective owner organization. It also is noteworthy that ownership of some key components may change during the lifecycle of the proposed system. To make this solution truly scalable, one alternative is that the data processing components be adopted by one or more commercial data service providers, which would have the resources to expand this system nationally by recouping the value of having the data. This business model is one consideration to note because it will impact the operating system in which parts of the proposed system runs, but it will not change the overall framework. External-facing data interfaces will be necessary among data producers and contributors, the processing components, and the data consumers because these systems will all likely reside in their own operating environments. Personnel, costs, and other operational environment considerations to support these operating systems will vary depending on the organization that operates the respective subsystem.

Figure 3 illustrated the context diagram for the TDEI system that was proposed in the ConOps. Please note that this figure is a context diagram, not a functional systems diagram or a system architecture diagram. Primary interfaces with external systems involve primarily the data flows from the data producers and contributors (e.g., pedestrian-built environment, transit station/service, etc.) defined in the “Information Collection” function, as these interfaces will have to be established for each data resource. An example of this model is how transit agencies from across the world generate GTFS data, which are then accessed by companies, such as Google and applications such as the Transit App, to deploy navigation applications that use those data. Other interfaces with external systems include processed data flows to applications that serve end users, although the proposed system aims to establish a defined API to facilitate this sharing of data to interested data consumers. Each subsystem and its components, in the context of the ITS4US Program, can be subdivided into several different efforts. These efforts include the following:

- Components that the UW Team will directly develop and test, which primarily include the data validation and data services technologies that serve as the focal point for this project. In the context of **Figure 3**, these components are labeled with a “1” and include the data extraction and collection pipelines, as well as the data repository itself.
- Components that the UW Team will assist in developing to encourage data contributions, namely tool sets through which the data providers will be encouraged to submit data. In the context of **Figure 3**, these items are labeled with a “2” and consist of tool sets that will serve groups, such as municipal governments, transit agencies, and other data providers.
- Components that represent software demonstrations whose development the UW Team will support to demonstrate the success of the pipelines. These include the three applications that have been vetted to provide the services needed by underserved end users. In the context of **Figure 3**, these components are labeled with a “3” and include Multimodal AccessMap from the Taskar Center for Accessible Technology at the University of Washington (TCAT), the Digital Twin applications and Microsoft's Soundscape.
- Other components that provide data used within the TDEI and that both already exist and can be obtained via existing APIs operated by data service providers, such as weather and topographic elevation data, are shown in **Figure 3**, but are not labeled with a number. Similarly, third-party applications, which will be supported by the TDEI, but that are not part of the formal TDEI deliverables, are not labeled with a number.

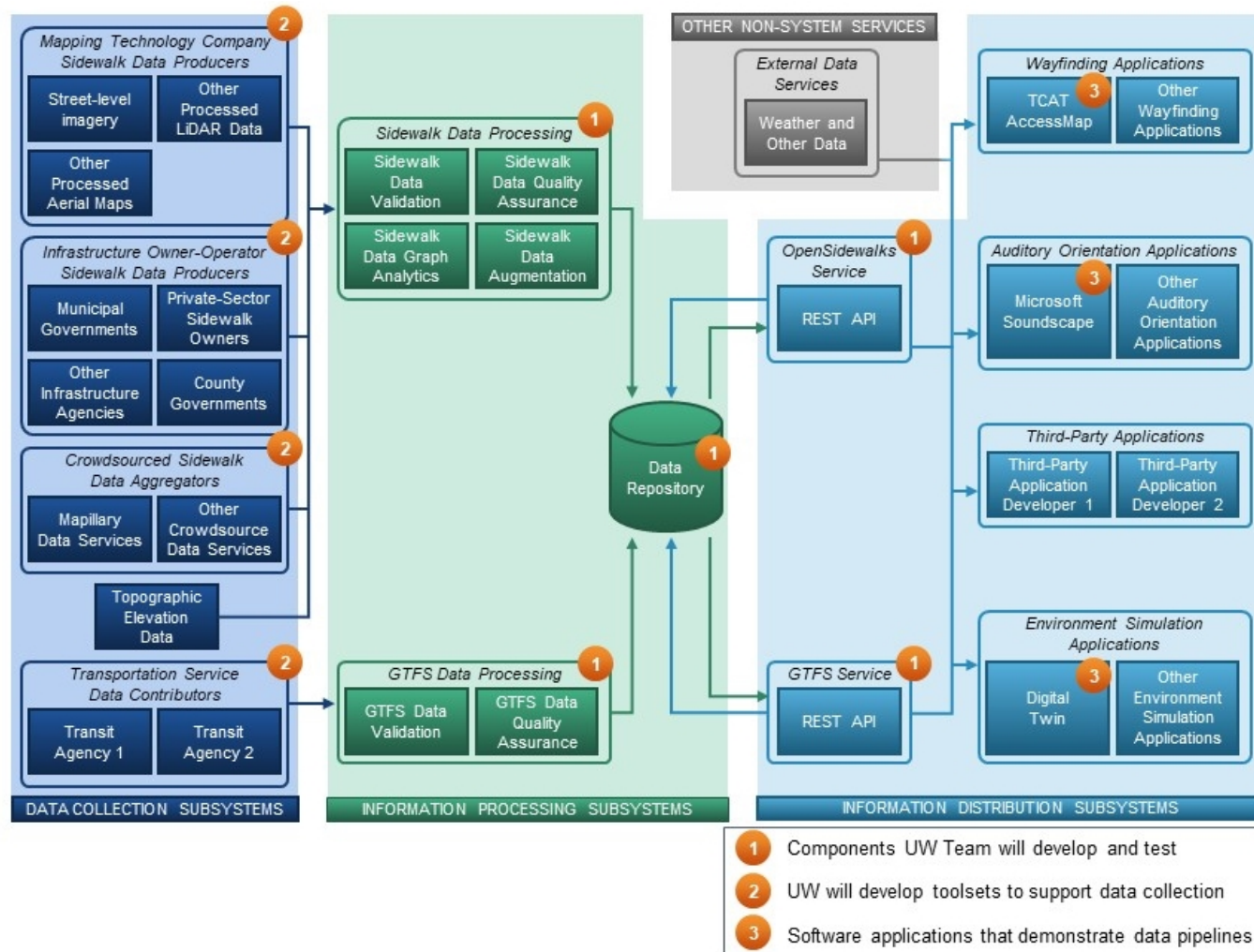


Figure 3. Diagram. Context diagram for the proposed Transportation Data Equity Initiative system.

Source: University of Washington and Cambridge Systematics.

2.2. System Modes and States

The proposed system is designed for full operation, with redundancies built into its design to allow for failover during potential disruptions of service (based on the policies of the organizations that host the components that make up the system). Preserving reliable uptime will help encourage use and facilitate wider adoption by interested parties. That said, when issues occur, several modes of operation are anticipated. These modes include the following:

- **Normal Mode of Operation**—Proposed system comprehensively operates as expected. All users perceive the system to be in a functional state. No operations-related errors are reported among any of the components.
 - **Example:** Regular, everyday use of the data repository, mobile applications, and data collection tools.
- **Disrupted Mode of Operation**—Proposed system experiences a disruption, but is able to continue operation with all capabilities present. All users perceive the system to be in a functional state. Operations-related errors may be reported internally to the component that is disrupted for maintenance review.
 - **Example:** The data repository server fails and goes offline, forcing an automatic failover to a backup recovery server site that houses copies of the data repository and can operate the same processes as the primary server.
 - **Example:** A mobile application used for demonstration has a network communications issue, forcing a failover to a backup site to provide application functions.
- **Degraded Mode of Operation**—Proposed system loses a critical component, either partially or fully, but is able to run at a degraded state due to other components remaining functional. Users may or may not notice outages in part or all of the system that impacts their ability to use it. Operations-related errors are reported internally among all components affected by the loss.
 - **Example:** The data repository goes offline, and automatic failover to the backup site does not occur. Some data producers, contributors, and aggregators receive errors when they upload data. Applications continue to operate using historical data stored by the application, but end users may receive outdated information.
 - **Example:** One of the demonstration applications is corrupted, causing it to cease function. All other functions operate properly. End users utilizing other demonstration applications observe no issue, but end users utilizing the failed application will not receive service.
- **Failed Mode of Operation**—Proposed system fails because of a critical component loss that prevents any operation. Users immediately take note of this outage because no services are available in any capacity. Operations-related errors are reported among all components. A complete loss of components is unlikely due to the distributed architecture of the proposed system, but the mode of operation remains possible under select circumstances.
 - **Example:** A large-scale cybersecurity intrusion occurs, and parts of the TDEI system are affected, forcing these components to be taken offline. Data generators attempting to generate data are immediately informed that the tool is not operating properly. End users requesting services through their applications immediately are informed that the application is offline.

Further details on the specific modes of operation can be found in the ConOps.

2.3. Major System Capabilities

The proposed system comprises various subsystems. Generally speaking, a subsystem is made up of several major system components that internally work together to collect, process, and distribute information within that subsystem, often by coupling relevant existing components to a new component. In the case of the proposed system, many of the components are developed and significantly modified in order to accommodate and produce a complete system. As a result, the overall system is decomposed into many relevant subsystem services, with each subsystem serving a distinct role in collecting, processing, and distributing data. The subsystems for the proposed system are summarized in **Table 2**.

Table 2. Summary of the services that form part of the Transportation Data Equity Initiative and their function in the context of the proposed system.

Subsystem Services	Main Functions
Data Collection— Mapping Technology Company Sidewalk Data Producer Services	These services manage the conversion of satellite imagery data, LiDAR, and photo imagery data into sidewalk attribute data. Participating mapping service companies may leverage the TDEI system's data schema validation tools to ensure that the data produced follows the OpenSidewalks data schema before they are submitted to the data repository.
Data Collection— Infrastructure Owner- Operator Sidewalk Data Producer Services	These services manage the ingestion of existing pedestrian-built environment data in the OpenSidewalks format into the TDEI system. These services may offer some conversion tools for some of the most common data formats held by infrastructure operators. Data producers who produce data in esoteric formats may have to leverage the TDEI system's data collection tools to participate in the TDEI system. Participating data producers may leverage the TDEI system's data schema validation tools to ensure that the data produced follows the OpenSidewalks data schema before they are submitted to the data repository.
Data Collection— Crowdsourced Sidewalk Data Aggregator Services	These services manage the conversion of crowdsourced sidewalk data into the OpenSidewalks data standard. Participating data producers may leverage the TDEI system's data validation tools to ensure that the data produced (e.g., asset condition) follows the OpenSidewalks data schema before they are submitted to the data repository. Trusted community organizations also may be tasked with manual validation of sidewalk data and attributes, using the TDEI system's data vetting tools, before those changes are published through the TDEI system.

Subsystem Services	Main Functions
Data Collection— Transportation Service Operators Data Contribution Services	These services manage the ingestion of transit feed data into the appropriate GTFS-Flex extended data schema. Participating transportation service operators may use TDEI system's data collection services. All data collected by participating transportation service providers will be published on a Web service; either open to the public or through a requested API service.
Data Processing— Sidewalk and Indoor Pathway Data Validation Services	These services manage the automated and manual validation and quality assurance checks of sidewalk and indoor pathway data prior to their acceptance in the TDEI. With various data sources contributing to the data repository, these validation services will validate any contributed data and prepare it for integration to generate an updated graph network in accordance with the relevant TDEI data schema.
Data Processing— GTFS-Flex Data Validation Services	This service manages the automated and manual validation and quality assurance checks of GTFS data feeds prior to their storage in the data repository.
Data Processing— Sidewalk Data and Indoor Pathway Update and Modification Services	These services manage the automated integration of updated whole data sets or collected changes to sidewalk and indoor pathway data to enable integrating updates to the TDEI. With various data sources contributing updates to the data repository, these update services attempt to generate an updated graph network in accordance with the TDEI data schemas.
Data Processing— GTFS-Flex Update Services	These services manage the automated integration of updated whole data sets or collected changes to on-demand service data to enable integrating updates to the TDEI. With various data sources contributing updates to the data repository, these update services attempt to coordinate updated distributions to the GTFS-Flex data in accordance with the TDEI data schema.
Information Distribution— OpenSidewalks Service Subsystem	This subsystem manages the distribution of sidewalk data to application services and other external sources that make requests. It will need to provide a specification for the OpenSidewalks API, which will need to be updated as new versions of the OpenSidewalks data schema are developed.
Information Distribution— GTFS Service Subsystem	This subsystem manages the distribution of transit data to application services and other external sources that make requests. It will need to provide a specification for the GTFS API, which will need to be updated as new extensions are added to the GTFS data schema.

Subsystem Services	Main Functions
Information Distribution— Wayfinding Application Subsystem	This subsystem includes application services that query the data repository for sidewalk and transit data, receive those data, process them into their own user interface, and then provide useful A-to-B wayfinding and urban exploration information to end users with mobility limitations. At the initial phase of the project, Multimodal AccessMap may serve as a demonstration application for this subsystem. Other third-party application services that focus on wayfinding may be added to this subsystem as part of subsequent efforts.
Information Distribution— Auditory Orientation Subsystem	This subsystem includes application services that query the data repository for sidewalk and transit data, receive those data, process them into their own user interface, and then provide useful navigation information for spontaneous travel scenarios for blind, vision disabled, or deafblind digital device end users. At the initial phase of the project, Microsoft's Soundscape may serve as a demonstration application for this subsystem. Other third-party application services that focus on auditory navigation may be added to this subsystem as part of subsequent efforts.
Information Distribution— Environment Simulation Subsystem	This subsystem includes application services that query the data repository for transit station facility description data, receive those data, process them and disseminate them through their own user interface, and then provide useful navigation information for pretrip visualization and exploration of a potentially multilevel transit station. At the initial phase of the project, an application will be identified to serve as the demonstration application for this subsystem. Other third-party application services that focus on pretrip augmented reality experiences may be added to this subsystem as part of subsequent efforts.
Information Distribution— Third-Party Application Subsystem	This subsystem includes all other application services that are both third-party (i.e., independent of the proposed system's development) and not a wayfinding, auditory orientation, or environment simulation application. Similar to other information distribution subsystems, application services within this subsystem will query the data repository for sidewalk and transit data, receive those data, process and disseminate them through their own interface, and then provide useful information to digital device end users that aligns with the services offered by that application.
Other Supporting Systems—External Data Services	External data services may include a weather data service to provide meteorological weather data of relevance to the proposed system. These data service providers should experience no modifications to their existing systems, except as a request to connect to their data service.

Source: University of Washington and Cambridge Systematics.

2.4. Major System Conditions, Constraints, Assumptions and Dependencies

2.4.1. System Assumptions

In the context of the proposed system, the following assumptions apply:

- OpenSidewalks is accepted as a sidewalk pathway tool.
- GTFS remains the standard for fixed-route transit service.
- GTFS-Pathways and associated extensions are formally adopted as standard and used by transit agencies.
- GTFS-Flex extension is formally adopted as the standard and used by transit agencies.
- The system will be economically scaled.
- Existing software and services are modified to support new data feeds.
- Contributors actively participate in submitting data in the proposed data standards.
- The system will operate on its own with minimal administrator involvement in terms of setting up data.

2.4.2. System Constraints

In the context of the proposed system, the following constraints apply:

- The stakeholder population is limited to certain groups as part of the design, namely, people with disabilities, older adults, or anyone who belongs to one or more of the following categories:
 - People who experience difficulties accessing pedestrian environments without being provided detailed prior knowledge about the infrastructure connectivity and built environment (either for lack of accessibility or safety information or signage in their native language).
 - People who use demand-responsive transit options (e.g., Dial-a-Ride or paratransit services).
 - People who need prior knowledge about transit stations or transit stops because of their reliance on accessibility features within the transit infrastructure (e.g., the need to use elevators and not stairs or escalators, or the need to identify the location of ticket machines before using an elevator).
 - People who experience difficulty with typical mobility applications because they are not built with accessibility features in mind.
- The proposed system will utilize the OpenSidewalks data schema to map the pedestrian network.
- The proposed system will utilize GTFS and its associated extensions as part of the transit feed data collection.

- The proposed data standards for this project (draft or adopted) have outlined data schema, which provides a limited, but defined, number of data inputs that can be received by the proposed system.
- The proposed system intends to provide services to end users by utilizing standards that are still under development, namely the proposed GTFS extensions.
- The proposed system intends to provide its services through the existing AccessMap platform, which will be modified to accommodate enhanced data feeds (new version will be referred to as Multimodal AccessMap).
- The proposed system intends to provide its services through the existing Soundscape platform, which will be modified to accommodate enhanced data feeds.
- The proposed system intends to provide its services through the proposed Digital Twin platform, which will be developed to accommodate enhanced data feeds.
- The proposed system is designed to be employed in any feasible location geographically, meaning it could be launched in any environment with relative ease if the right criteria were present (e.g., existence of pedestrian built-environment or existence of transit services, etc.). However, as a data service, its coverage is limited to areas where data are being collected and reported by these services.

2.4.3. Operational Policies and Constraints

The proposed system is subject to these policies that may govern system operation, as well as constraints that factor into the development, operation, or maintenance of the system:

- The proposed system comprehensively will adopt policies that restrict use of personally identifiable information (PII) to protect user privacy.
- The proposed system and its components will be operational 99.5 percent of the time, 24 hours a day, 7 days a week, 365 days per year.
- Parties participating in the proposed system will need to comply with the defined data standards that are used, namely the OpenSidewalks and GTFS data schema.
- The UW team will maintain the core portion of the proposed system, namely the data repository, as part of Phase 2 and Phase 3 of the ITS4US Program.
- All demonstration applications shall classify their services as “for information only” with no guarantee or expectation that the supporting data is accurate.

2.5. User Characteristics

Users (otherwise referred to as actors in the ConOps), as presented in **Table 3**, represent the stakeholders that will interact with the proposed system in some way. Unlike other stakeholders, actors directly use the existing system components in some capacity as part of their operations. While often representing end users, users can include data contributors and application developers with a role in the proposed system. Users for the TDEI system are divided among the following user classes, representing groups of users defined by how they interact with the system. Note that specific organizations can fit into one or more of these functional categories:

1. **Data Generators (DG)**—Entities in this group include **data producers** from governmental bodies, transportation agencies, or the private sector. Governmental bodies and transportation agencies that own and operate sidewalk infrastructure or transportation hubs typically produce data about these assets. Private-sector data companies typically produce data about travel environments in support of their own mobile applications, some of their customers who consume these data, and digital cartography. Entities in this group may or may not be regulated under other data collection requirements and/or restrictions.
2. **Transportation Service Providers (TS)**—Entities in this group include **data contributors** from public- or private-sector transit agencies or transportation operators. They may offer fixed-route or on-demand transit service; or may own, operate, and maintain transit station facilities. This user group wishes to inform customers of transportation service or transit station facility options, and may share data directly with application developers or make data available to data aggregators.
3. **Data Service Providers (DS)**—Entities in this group include both transportation service providers that make their own data available to outside application developers and, more importantly, **data aggregators** that obtain data from multiple sources (e.g., transit service data from multiple transit agencies, or sidewalk data from multiple cities); fuse those data into a seamless data structure; and provide that seamless data structure to application developers.
4. **Application Developers (AD)**—Entities in this group include **data consumers** that create digitally based, user-facing applications with data from public- or private-sector organizations that disseminate data for mapping or travel. Application developers depend on the availability of data from providers of those data to generate solutions that meet the needs of digital-device-users.
5. **Digital Device End Users Experiencing Travel Barriers (DU)**—Users in this group include a specific group of **data consumers**, primarily individuals with the lived experience of some disability or their caretakers who utilize digital cartography and information to make informed travel decisions. These decisions include, but are not limited to, identifying optional routes for desired trips and obtaining specific navigational directions for route plans they select. The needs of the end users drive the intent and design of the applications, but not the data tools and infrastructure.

Although these actors/user classes will all utilize the proposed system in some capacity, each actor/user class is organizationally separate from one another. Users within a user class may have some organizational relationship (e.g., municipal sidewalk owner and transit agency), but that relationship is not relevant in the context of the proposed system. Some of the user classes—namely the data producers that publish sidewalk data—also may become end users that utilize the data for their own activities, such as communities that contribute sidewalk data, and also provide information services on transit station pathways to their citizens.

Table 3. Transportation Data Equity Initiative actors and interaction with the proposed system.

Actor/User Class	Type	Short Description	Changes to Responsibilities and Interaction with the Proposed System
Municipal Infrastructure Owner-Operators	D	Governmental bodies that own, operate, and maintain pedestrian-built environments.	User converts available sidewalk information into OpenSidewalks data schema and submits data to the proposed data repository.
Private-Sector Pedestrian-Built Environment Owner-Operators	Data Generator	Private-sector infrastructure owner-operators who own, operate, and maintain pedestrian-built environments.	User converts available sidewalk information into OpenSidewalks data schema and submits data to the proposed data repository.
Elevation Data Provider	Data Generator	Public- or private-sector organizations in the business of collecting topographic elevation data.	User converts available elevation information into OpenSidewalks data schema and submits data to the proposed data repository.
Transit Agencies	Transportation Service Provider	Public- or private-sector transit agencies or transportation operators that offer fixed-route or on-demand transit service; and may own, operate, and maintain transit station facilities.	User may need to expand their GTFS extension offerings and submit data to the proposed data repository. User also may be responsible through its paratransit operations for collecting or vetting sidewalk data.
Crowdsourced Sidewalk Reporters	Data Service Provider	Private citizens who utilize sidewalks and have the capability to report condition data.	User utilizes a tool to report sidewalk condition or attribute data to the proposed data repository.
Mapping Services	Data Service Provider	Private-sector organizations in the business of mapping pedestrian-built environment data.	User converts the data that are being collected into OpenSidewalks data schema and submits data to the proposed data repository.

Actor/User Class	Type	Short Description	Changes to Responsibilities and Interaction with the Proposed System
Weather Data Provider	Data Service Provider	Public- or private-sector meteorological organizations in the business of collecting weather data.	User may need to add the proposed system as an allowable data user.
Multimodal AccessMap Developers	Application Developer	Developers of the current service provider of sidewalk data.	User may need to expand service area based on location of data contributed. User may need to update reporting features based on new data schema and capabilities.
Soundscape Developers	Application Developer	Developers of the current provider of audible cue information services.	User may need to expand service area based on location of data contributed. User may need to expand reporting features based on new data schema and capabilities.
Digital Twin Developers	Application Developer	Developers of the current provider of visual built environment data services.	User may need to expand service area based on location of data contributed. User may need to expand reporting features based on new data schema and capabilities.
Third-Party Application Developers	Application Developers	New application developers that aim to provide a service to end users.	User accesses the associated API for sidewalk and transit data from the proposed system, as desired.
Travelers with Sidewalk Preferences	End User	Travelers with routing and urban exploration preferences in sidewalk environments.	End users access the proposed system through their respective application. The system internally moves the data to service their request.
Blind, Vision Disabled, or Deafblind Travelers	End User	Travelers who wish to explore new, unfamiliar pedestrian environments.	End users access the proposed system through their respective application. The system internally moves the data to service their request.

Actor/User Class	Type	Short Description	Changes to Responsibilities and Interaction with the Proposed System
Travelers with Hearing Disabilities	End User	Travelers who benefit from additional navigation information when utilizing sidewalks or transit services.	End users access the proposed system through their respective application. The system internally moves the data to service their request.
Sighted Older Adults	End User	Travelers who seek to explore, assess, and visualize a trip path through a transit station in advance of making a trip.	End users access the proposed system through their respective application. The system internally moves the data to service their request.
Low-Income Transit Users	End User	Travelers who utilize public transportation in lieu of a more costly personal automobile.	End users access the proposed system through their respective application. The system internally moves the data to service their request.
Rural Transit Users	End User	Travelers in rural areas who utilize transit services, including on-demand services.	End users access the proposed system through their respective application. The system internally moves the data to service their request.
Veterans	End User	Travelers who typically are in rural environments and need access to veterans' services.	End users access the proposed system through their respective application. The system internally moves the data to service their request.
Multilingual, Multicultural Travelers	End User	Travelers who seek to explore, assess, and visualize a trip path through a transit station in advance in a format that aligns with their native culture or language.	End users access the proposed system through their respective application. The system internally moves the data to service their request.

Source: University of Washington and Cambridge Systematics.

2.6. Operational Scenarios

This section summarizes the 13 operational scenarios, which also are referred to as use cases, presented in the ConOps. Each operational scenario describes the user need or issue that it is intended to address, as well as outcomes or benefits users are expected to gain through the deployment of the proposed system. These scenarios do not address all of the desired improvements, but serve to demonstrate some of the key needs. As illustrated in **Table 4**, operational scenarios are presented for both specific “user entities” that play key roles in the operation of the proposed system, and end users that directly benefit from the data to be collected and made available for distribution through a variety of Internet-enabled applications.

Table 4. Summary of operational scenarios.

Number	Scenario	Description	Actors Involved	End-User Benefit
1	Sidewalk data generation, collection, and vetting.	In this use case, a technology mapping company uses their proprietary visual and LiDAR imagery data to generate a routable sidewalk dataset using the OpenSidewalks data standard. That dataset describes a specific city's sidewalk network and includes all visual features, including sidewalk width. However, nonvisual features are added by incorporating data stored in city databases, which are conflated with the routable network to add those features to the network database.	<ul style="list-style-type: none"> • Large technology mapping companies. • Municipal infrastructure owner/operators. 	<ul style="list-style-type: none"> • Increased availability of sidewalk data and information. • Improved sidewalk data and information.
2	Vetting of sidewalk data and street crossing identification.	In this use case, the OpenSidewalks data service provider works with local active transportation and disability advocacy groups to vet sidewalk and street crossing data stored in the database.	<ul style="list-style-type: none"> • Data service provider that operates OpenSidewalks. • Organizations and individuals interested in vetting sidewalk, pathway, and street crossing data. • Organizations that promote active transportation. 	<ul style="list-style-type: none"> • Improved sidewalk data and information.

Number	Scenario	Description	Actors Involved	End-User Benefit
3	Generation and vetting of GTFS-Pathways data.	In this use case, transit agencies that own and operate major transit centers will use tools and procedures developed in this project to generate and publish GTFS-Pathways data.	<ul style="list-style-type: none"> Owner/operator of complex transit centers. Data aggregators of GTFS-Pathways data. Application developers. 	<ul style="list-style-type: none"> Increased availability of GTFS-Pathways extension data and information on transit sidewalk infrastructure. Improved GTFS-Pathways data.
4	Generation and vetting of GTFS-Flex data.	In this use case, transit agencies that fund or operate on-demand transit services will use tools and procedures developed in this project to generate and publish GTFS-Flex data.	<ul style="list-style-type: none"> Agencies funding on-demand transit services. Operators of on-demand transit services. Data aggregators of GTFS-Flex data. Application developers that desire access to detailed data about on-demand transit services. 	<ul style="list-style-type: none"> Increased availability of GTFS-Flex extension data and information on on-demand transit service.

Number	Scenario	Description	Actors Involved	End-User Benefit
5	Individual with mobility disability uses verified sidewalk and transit data to navigate through several cities.	In this use case, a digital device end user who has mobility impairments wishes to navigate from an origin to a destination using sidewalks and transit services that are available and can accommodate their specific travel preferences. The local city has previously mapped their sidewalk environment and sent it to the data repository for validation and storage. A transit agency within the same region also produced fixed-route transit service schedule information, using the GTFS standard, and sent it to the data repository. The Multimodal AccessMap application, which assists a user with a mobility disability in this scenario, draws from this data repository. The digital device end user uses Multimodal AccessMap to navigate from their origin to destination successfully.	<ul style="list-style-type: none">• Travelers with sidewalk preferences.• Municipal infrastructure owner-operators.• Crowdsourced sidewalk reporters.• Transit agencies.• Multimodal AccessMap developers.	<ul style="list-style-type: none">• Navigation from origin to destination with integration of comprehensive sidewalk and transit data.

Number	Scenario	Description	Actors Involved	End-User Benefit
6	Veteran with mobility disability traveling from a rural home to the Veterans Affairs (VA) hospital for a medical appointment.	In this use case, a digital device end user in a rural community who does not own a personal vehicle wishes to navigate from an origin to a destination, using sidewalks and transit services that are available. Some sidewalk data have been mapped by the local municipality and sent to the data repository, but—being a rural area—the available infrastructure is extremely limited. The local transit agency offers paratransit services and reports this service data to the data repository using the GTFS-Flex data standard. Once the digital device end user confirms their eligibility for paratransit service through their traditional method, they use Multimodal AccessMap to locate paratransit services.	<ul style="list-style-type: none">• Rural transit users.• Municipal infrastructure owner-operators.• Transit agencies.• Multimodal AccessMap developers.	<ul style="list-style-type: none">• Navigation from origin to destination with comprehensive GTFS-Flex data and information on on-demand transit service.

Number	Scenario	Description	Actors Involved	End-User Benefit
7	Blind, vision disabled, or deafblind individual uses verified sidewalk and transit data.	In this use case, a digital device end user who is blind or deafblind wishes to explore the environment, understanding the neighborhood they are moving through while they navigate from an origin to a destination using sidewalks and transit services that are available and can accommodate their travel preferences. Mapping data for that user's city has been collected through a mapping technology company, which has produced general sidewalk information with attributes in the OpenSidewalks data format and submitted it to the data repository. Similarly, a local community of crowdsourcers is active in the area, providing corrections to any data errors. Soundscape, a navigation and exploration application for blind, vision disabled, or deafblind users, draws from the data repository and enables a user to navigate from their home to a shopping destination.	<ul style="list-style-type: none"> • Blind, vision disabled, or deafblind travelers. • Municipal infrastructure owner-operators. • Crowdsourced sidewalk reporters. • Transit agencies. • Soundscape developers. 	<ul style="list-style-type: none"> • Navigation from origin to destination with integration of comprehensive sidewalk and transit data.
8	Multilingual tourist tries to conduct pretrip planning for a multilevel transit station.	In this use case, an international tourist—whose primary language is not English—uses Unity Digital Twin to preplan their trip through a large, complex United States (US) transit station. The transit agency previously utilized GTFS-Pathways to digitally represent the transit station. This information was published in the data repository.	<ul style="list-style-type: none"> • Multilingual, multicultural travelers. • Municipal infrastructure owner-operators. • Transit agencies. • Digital Twin developers. 	<ul style="list-style-type: none"> • Pretrip planning with comprehensive mapping of transit station features and GTFS-Pathways data.

Number	Scenario	Description	Actors Involved	End-User Benefit
9	Low-income traveler utilizes a third-party application (One-Call/One-Click Service) to reach a destination.	In this use case, a third-party application developer utilizes sidewalk data and GTFS transit data to provide an enhanced one-call/one-click service for underserved user groups. The sidewalk data, which is collected by local cities or communities and verified, and the GTFS transit data, is stored in a central data repository. The third-party application is able to provide multimodal directions via a phone service, benefiting low-income users that may not have data plans and could not previously participate in services offered by other three mobile applications.	<ul style="list-style-type: none"> • Low-income transit users. • Municipal infrastructure owner-operators. • Transit agencies. • Third-party application developers. 	<ul style="list-style-type: none"> • Navigation from origin to destination with integration of comprehensive sidewalk and transit data.
10	Travelers with sidewalk preferences utilize data generated by a city government.	In this use case, a city government launches an initiative to improve their pedestrian environment for mobility disabilities. As part of the initiative, they decide to map their sidewalk environment. Coordinating with Multimodal AccessMap, their sidewalk data are integrated into the navigation application.	<ul style="list-style-type: none"> • Travelers with sidewalk preferences. • Municipal infrastructure owner-operators. • Multimodal AccessMap developers. 	<ul style="list-style-type: none"> • Increased availability of sidewalk data and information. • Improved sidewalk data and information. • Navigation from origin to destination with integration of comprehensive sidewalk data.

Number	Scenario	Description	Actors Involved	End-User Benefit
11	Travelers with sidewalk preferences utilize data generated by civic organization.	In this use case, a local nonprofit committed to accessibility decides to produce detailed sidewalk data for integration with Multimodal AccessMap. They coordinate with the application in order for their data to follow the correct standards and be integrated into the application's central data repository.	<ul style="list-style-type: none"> Travelers with sidewalk preferences. Crowdsourced sidewalk reporters. Multimodal AccessMap developers. 	<ul style="list-style-type: none"> Increased availability of sidewalk data and information. Improved sidewalk data and information. Navigation from origin to destination with integration of comprehensive sidewalk data.
12	Travelers with sidewalk preferences utilize data generated by an aerial mapping company's analytics engine for aerial images.	In this use case, a large aerial mapping company decides to produce an analytics engine capable of generating sidewalk data. They coordinate with Multimodal AccessMap to ensure the correct data standards are followed. Their data are ultimately integrated with the navigation application, and users are able to utilize the sidewalk data for trip planning purposes.	<ul style="list-style-type: none"> Travelers with sidewalk preferences. Mapping services. Multimodal AccessMap developers. 	<ul style="list-style-type: none"> Increased availability of sidewalk data and information. Improved sidewalk data and information. Navigation from origin to destination with integration of comprehensive sidewalk data.

Number	Scenario	Description	Actors Involved	End-User Benefit
13	Transit users utilize GTFS-Flex and GTFS-Pathway extensions through a navigation application.	In this use case, a regional transit agency decides to include the GTFS Pathways and Flex extensions in their weekly GTFS dataset. Once they do so, this use case also demonstrates the automatic integration with Multimodal AccessMap and the improved user experience.	<ul style="list-style-type: none">• Travelers with sidewalk preferences.• Transit agencies.• Multimodal AccessMap developers.	<ul style="list-style-type: none">• Increased availability of transit data, through GTFS-Pathways and Flex extensions.• Navigation from origin to destination with integration of comprehensive transit data.

Source: University of Washington and Cambridge Systematics.

3. System Capabilities, Conditions, and Constraints

This section includes categories of requirements covering system capabilities, conditions, and constraints. They have been developed based on the user needs and operational scenarios, as presented in the ConOps, as well as the DMP, SMP, and PMESP.

For each requirement, the following information is provided:

- **SyRS ID**—A unique ID by which to identify the system requirement.
- **Requirement**—Description of the requirement that fulfills part of, or a complete User Need, as documented in the ConOps.
- **Verification Method**—Method used to verify each requirement. The recommended verification methods are as follows:
 - **Analysis**—This method describes the use of analytical data, analysis, or simulations under defined conditions to show theoretical compliance and is used where testing to realistic conditions cannot be achieved or is not cost effective. Analysis (including simulation or simple logical conclusion) may be used when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution.
 - **Demonstration**—This method uses a set of test activities with system stimuli (actual or simulated) selected by the system developer that may be used to show that system or subsystem response to stimuli is suitable. This is the primary method to test functional capability.
 - **Inspection**—This method describes an examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation (e.g., platform compliance).
 - **Test**—This method describes an action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated.
- **Priority Level**—Classifies each requirement as high, medium, or low. The definitions for each level are as follows:
 - **High**—Requirements are deemed essential for the new system.
 - **Medium**—Requirements are deemed desirable for the new system.
 - **Low**—Requirements are deemed optional for the new system.

Refer to **Appendix B** for the user needs-to-system requirements traceability matrix.

3.1. Functional System

This section describes high-level system requirements, which contain the core functionality of the system and needs. The requirements of the functional system have been categorized into 15 data lifecycle activities.

3.1.1. Data Description

Table 5 presents the system requirements related to the activities of identifying and documenting the data with extended metadata to allow for understanding, harvesting, and consuming the data itself.

Table 5. Transportation Data Equity Initiative data description functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-DE-01	Data standards shall use attributes that support travel preferences of travelers.	Inspection	High
F-DE-01.01	Pedestrian built environment shall be described using the OpenSidewalks data standard.	Inspection	High
F-DE-01.02	Transportation stations and hubs shall be described using the GTFS-Pathways data standard.	Inspection	Medium
F-DE-01.03	Demand responsive travel services shall be described using the GTFS-Flex data standard, excluding real-time feeds.	Inspection	High
F-DE-02	The TDEI system shall utilize a common data model.	Inspection	Medium
F-DE-03	The TDEI system shall provide guidance/guidelines for its participants that is easily understood without the need for specialized training.	Inspection	High
F-DE-03.01	Guidance/guidelines shall be provided through data standard specifications.	Inspection	High
F-DE-03.02	Guidance/guidelines shall be provided through data standard schemas.	Inspection	High
F-DE-03.03	Guidance/guidelines shall be provided through coding instructions.	Inspection	High
F-DE-03.04	Guidance/guidelines shall cover generating data in approved formats.	Inspection	High

SyRS ID	Requirement	Verification Method	Priority
F-DE-03.05	Guidance/guidelines shall cover quality assurance requirements of the data.	Inspection	High
F-DE-03.06	Guidance/guidelines shall cover accessing data.	Inspection	High
F-DE-04	Data standard specifications shall be publicly available.	Inspection	High
F-DE-04.01	Data standard specifications shall include OpenSidewalks, GTFS-Flex, and GTFS-Pathways.	Inspection	High
F-DE-04.02	Data standard specifications shall be published.	Inspection	High
F-DE-04.03	Data standard specifications shall be version-tracked.	Inspection	High
F-DE-04.04	Data standard specifications shall be vetted.	Inspection	High
F-DE-04.05	Data standard specifications shall include a data dictionary.	Inspection	Medium
F-DE-04.06	Data standard specifications shall contain standardized metadata.	Inspection	High
F-DE-04.06.01	Metadata shall describe the origin of collected data.	Inspection	Medium
F-DE-04.06.02	Metadata shall indicate metrics for reviewers to determine the level of accuracy/completeness.	Inspection	High
F-DE-04.06.03	Metadata shall describe the data standards and structure.	Inspection	High
F-DE-04.07	Data standard specifications shall include governance provisions that allow for effective management of data updates and revisions.	Inspection	High
F-DE-04.08	Data standard specifications shall include specified allowable values and error tolerance levels for data standard elements and attributes, where applicable.	Inspection	High
F-DE-05	Data standard specifications shall be scalable in different geographic markets or to different user populations.	Inspection	High
F-DE-06	Data standard specifications shall be extensible in different geographic markets or to different user populations.	Inspection	High

SyRS ID	Requirement	Verification Method	Priority
F-DE-07	Data standard specifications shall be interoperable in different geographic markets or to different user populations.	Inspection	High
F-DE-08	Data standard schemas shall be made available to data generators.	Inspection	High
F-DE-08.01	Data standard schemas shall include information about the database structure and database metadata.	Inspection	High
F-DE-08.02	Data standard schemas shall use standard classifications and vocabularies for defining attributes and specifications.	Inspection	High

Source: University of Washington and Cambridge Systematics.

3.1.2. Data Extensibility

Table 6 presents the system requirements related to the activities of identifying and documenting new data attributes or data types to allow for data schema extensions and dynamic growth.

Table 6. Transportation Data Equity Initiative data extensibility functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-EX-01	Updates to the data schema structure shall follow a formal update process.	Inspection	High
F-EX-02	Notifications shall be provided to approved TDEI system users when data schema updates occur.	Demonstration	High
F-EX-03	Data standards used in the TDEI system shall be open sourced.	Inspection	High

Source: University of Washington and Cambridge Systematics.

3.1.3. Data Collection

Table 7 presents the system requirements related to the point at which new and/or existing data are collected or generated.

Table 7. Transportation Data Equity Initiative data collection functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-CO-01	The TDEI system shall be capable of receiving data from multiple sources.	Demonstration	High
F-CO-01.01	The TDEI system shall be capable of receiving sidewalk data from data generators.	Demonstration	High
F-CO-01.02	The TDEI system shall be capable of receiving external third-party data for relevant optional attributes, such as subjective path characteristics like presence of bushes.	Demonstration	High
F-CO-01.03	The TDEI system shall be capable of receiving fixed-route transit data from transportation service providers.	Demonstration	High
F-CO-01.04	The TDEI system shall be capable of receiving on-demand transit data from transportation service providers.	Demonstration	High
F-CO-01.05	The TDEI system shall be capable of receiving transit station layout data from transportation service providers.	Demonstration	High
F-CO-01.06	The TDEI system shall be capable of receiving data from crowdsourced applications to enable private citizens to identify needed local map updates and vet data submitted by others.	Demonstration	High
F-CO-02	The built environment features received by the TDEI system shall adhere to the following:	Demonstration	High
F-CO-02.01	The built environment features shall be tagged correctly in the data schema.	Demonstration	High
F-CO-02.02	The built environment features shall be able to support nongraphic representation.	Demonstration	High
F-CO-02.03	The built environment features shall be described in such a way that digital device end users can indicate their preferences without requiring additional explanation or training.	Demonstration	High
F-CO-03	The TDEI system shall provide data translation tools.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
F-CO-03.01	The TDEI system shall provide tools for sidewalk data producers to translate existing sidewalk data into the OpenSidewalks data format.	Demonstration	High
F-CO-03.02	The TDEI system shall provide tools for transit data producers to translate existing fixed-route data into the GTFS data format and associated extensions.	Demonstration	High
F-CO-03.03	The TDEI system shall provide tools for transit data producers to translate existing on-demand data into the GTFS data format and associated extensions.	Demonstration	High
F-CO-03.04	The TDEI system shall provide tools for transit data producers to translate existing transit station data into the GTFS data format and associated extensions.	Demonstration	High
F-CO-04	The TDEI system shall provide data collection tools.	Demonstration	High
F-CO-04.01	The data collection tools shall convert data into compatible or conflatable to the refined data standards for OpenSidewalks, GTFS data format or, where applicable, a comparable extension.	Demonstration	High
F-CO-04.02	The data collection tools shall include automated sidewalk data collection technologies (e.g., advanced analytics used by mapping technology companies) to populate sidewalk databases.	Demonstration	High
F-CO-04.03	The data collection tools shall include technologies that help generate data that describe on-demand transportation services.	Demonstration	Medium
F-CO-05	The TDEI system shall provide formal processes for uploading data and metadata.	Inspection	High

Source: University of Washington and Cambridge Systematics.

3.1.4. Data Processing

Table 8 presents the system requirements related to the activities associated with the necessary preparation of various new or existing acquired data inputs.

Table 8. Transportation Data Equity Initiative data processing functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-PR-01	The TDEI system shall develop the data processing components that accept submitted data.	Demonstration	High
F-PR-02	The TDEI system shall process extensible markup language (XML) OpenStreetMap (.osm) files.	Demonstration	High
F-PR-03	The TDEI system shall process GTFS Comma Separated Values (.csv) files.	Demonstration	High
F-PR-04	The TDEI system shall process JavaScript Object Notation (.json) files, including GeoJSON data formats.	Demonstration	High
F-PR-05	The TDEI system shall support processes for vetting the data.	Demonstration	High
F-PR-06	The TDEI system shall support processes for aggregating the data.	Demonstration	High
F-PR-07	The TDEI system shall support processes for managing the data.	Demonstration	High
F-PR-08	The TDEI system shall support processes for fusing the data.	Demonstration	High
F-PR-09	The TDEI system shall facilitate the processing of data into routable pathways networks.	Demonstration	High
F-PR-09.01	The routable pathway networks shall objectively describe the path infrastructure.	Demonstration	High
F-PR-09.02	The routable pathway networks shall include pathway locations.	Demonstration	High
F-PR-09.03	The routable pathway networks shall include pathway connectivity.	Demonstration	High
F-PR-09.04	The routable pathway networks shall include pathway features.	Demonstration	High
F-PR-09.05	The routable pathway networks shall include pathway characteristics.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
F-PR-09.06	The routable pathway networks shall include connectivity of features across different levels of transit stations.	Demonstration	High
F-PR-09.07	The routable pathway networks shall ensure that data linkages exist when different transit agencies share a physical transit stop.	Demonstration	Medium
F-PR-09.08	The TDEI system shall augment relevant links where connectivity exists.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.1.5. Data Quality Control

Table 9 presents the system requirements related to the activities to measure and monitor data quality to ensure that the data are usable at any stage of the data lifecycle.

Table 9. Transportation Data Equity Initiative data quality control functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-QC-01	The TDEI system shall require a data vetting process for all data before they are deposited into the core data repository to identify invalid data that have been reported.	Demonstration	High
F-QC-02	The TDEI system shall provide access to data vetting tools.	Demonstration	High
F-QC-02.01	The data vetting tools shall confirm whether the data conform to standards.	Demonstration	High
F-QC-02.02	The data vetting tools shall confirm whether the data are of sufficient accuracy.	Demonstration	High
F-QC-02.03	The data vetting tools shall confirm whether the data are of consistent quality.	Demonstration	Medium
F-QC-02.04	The data vetting tools shall describe when data are missing.	Demonstration	High
F-QC-02.05	The data vetting tools shall support automated data vetting activities (e.g., automated data review to check for data format and permissible data).	Demonstration	High

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SyRS ID	Requirement	Verification Method	Priority
F-QC-02.06	The data vetting tools shall support manual data vetting activities (e.g., owner/hired consultant review, community/organization reviews, traveler feedback).	Demonstration	High
F-QC-02.07	The data vetting tools shall generate a degree of confidence associated with the data being published.	Demonstration	High
F-QC-03	The TDEI system shall include the development of validation toolsets for assembling sidewalk and transit environment data from multiple providers.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.1.6. Data Storage

Table 10 presents the system requirements related to the activities of storing approved data into the core data repository.

Table 10. Transportation Data Equity Initiative data storage functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-ST-01	The TDEI system shall include the creation of the centralized data repositories.	Inspection	Medium
F-ST-02	The TDEI system shall include the operation of the centralized data repositories.	Inspection	Medium
F-ST-03	The TDEI system shall include the maintenance of the centralized data repositories.	Inspection	Medium
F-ST-04	The TDEI system shall transmit approved data to centralized data repositories.	Demonstration	High
F-ST-05	The data repository shall include fixed-route transit data.	Demonstration	Medium
F-ST-06	The data repository shall include on-demand transit data.	Demonstration	High
F-ST-07	The data repository shall include transit station data.	Demonstration	High
F-ST-08	The data repository shall include graphed sidewalk network data.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
F-ST-09	The data repository shall include mode transfer options.	Demonstration	High
F-ST-10	The data repository shall include travel environments that connect mode transfers or trip segments.	Demonstration	High
F-ST-11	The data repository shall include first- and last-mile options.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.1.7. Data Update

Table 11 presents the system requirements related to the activities that directly change the content of data (reformat, add in updated sidewalk information, etc.).

Table 11. Transportation Data Equity Initiative data update functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-UP-01	The data repository shall support continuous updates.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.1.8. Data Sharing/Data Publishing

Table 12 presents the system requirements related to the activities associated with making community data stores available through websites, Web services, data catalogues, etc.

Table 12. Transportation Data Equity Initiative data sharing/data publishing functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-SH-01	The TDEI system shall include data provisioning services that distribute data-on-demand for use in a variety of applications.	Demonstration	High
F-SH-01.01	Data that is shared through the TDEI system shall be published on a Web service, either open to the public or through a requested API service.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
F-SH-01.02	Data that is shared through the TDEI system shall be accessible for different geographic locations.	Demonstration	High
F-SH-02	The TDEI system shall support interoperable sharing.	Demonstration	High
F-SH-03	The TDEI system shall support two-directional communication channels between the central database and the organizations that “own” the facility or service being described with data.	Demonstration	Medium

Source: University of Washington and Cambridge Systematics.

3.1.9. Data Discovery

Table 13 presents the system requirements related to the activities involved in finding data based on metadata and/or provenance information.

Table 13. Transportation Data Equity Initiative data discovery functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-DI-01	The TDEI system shall use public-facing APIs to exchange data with application developers.	Demonstration	High
F-DI-02	The OpenSidewalks data service shall receive the request from the application through its open secure API.	Demonstration	High
F-DI-03	The OpenSidewalks data service shall verify via the application’s descriptive metadata.	Demonstration	High
F-DI-04	The OpenSidewalks data service shall request/query all relevant data from the data repository.	Demonstration	High
F-DI-05	The OpenSidewalks data service shall send all relevant data to the application that made the original request.	Demonstration	High
F-DI-06	The GTFS data service shall perform the following functionality:	Demonstration	High
F-DI-06.01	Receive the request from the application through its open secure API.	Demonstration	High
F-DI-06.02	Verify via the application’s descriptive metadata.	Demonstration	High

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SyRS ID	Requirement	Verification Method	Priority
F-DI-06.03	Request/query all relevant data from the data repository.	Demonstration	High
F-DI-06.04	Send all relevant data to the application that made the original request.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.1.10. Data Analysis

No requirements focused on activities associated with the exploration and interpretation of well-managed, processed data for the purpose of knowledge discovery.

3.1.11. Data Dissemination

Table 14 presents the system requirements related to the activities that involve the dissemination of data through applications for end users.

Table 14. Transportation Data Equity Initiative data dissemination functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-DS-01	The demonstration applications shall utilize the data returned by the TDEI data services to identify paths using the most up-to-date sidewalk and/or transit data (including any paths that involve a sidewalk path option or transit option, if requested or available).	Demonstration	High
F-DS-02	The demonstration applications shall utilize the data returned by the TDEI data services to screen those paths based on the user's trip-specific travel preferences.	Demonstration	High
F-DS-03	The demonstration applications shall utilize the data returned by the TDEI data services to provide one or more recommended routes, when such a route exists, to the end user.	Demonstration	High
F-DS-04	The TDEI system shall support the development of tools to make informed, customized travel decisions.	Demonstration	High
F-DS-04.01	The TDEI system shall utilize mobile applications to demonstrate the system by providing a sidewalk route based on user-defined travel preferences.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
F-DS-04.02	The TDEI system shall utilize mobile applications to demonstrate the system by providing paths through transit stations based on user-defined travel preferences.	Demonstration	High
F-DS-04.03	The TDEI system shall utilize mobile applications to demonstrate the system by providing on-demand transit options based on user-defined travel preferences.	Demonstration	High
F-DS-04.04	The TDEI system shall utilize mobile applications to demonstrate the system providing data that supports spontaneous navigation of an end user's local environment.	Demonstration	High
F-DS-05	The TDEI system's demonstration applications shall use interfaces that minimize confusion for targeted user groups.	Demonstration	High
F-DS-05.01	The TDEI system's demonstration applications shall help the traveler identify when errors have occurred.	Demonstration	High
F-DS-05.02	The TDEI system's demonstration applications shall provide "help" functions that allow users to quickly obtain information about how to safely navigate from their current location.	Demonstration	High
F-DS-06	The TDEI system's demonstration applications shall be designed to report data that is unavailable.	Demonstration	High
F-DS-07	The TDEI system's demonstration applications shall support the delivery of information to users in different formats (audio, text, tactile displays, language) based on the intended audience of the demonstration application.	Demonstration	High
F-DS-08	The TDEI system's demonstration applications shall provide information regarding transit service capabilities to help travelers avoid potential hazardous outcomes.	Demonstration	High
F-DS-09	The TDEI system's demonstration applications shall provide insight on areas where data quality is reported to be poor to help travelers make informed decisions.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
F-DS-10	The TDEI system's demonstration applications shall issue low-power warnings within the application.	Demonstration	Medium
F-DS-11	The TDEI system shall safeguard PII data deemed necessary for operation.	Inspection	High
F-DS-12	The TDEI system shall permit approved third-party mobile applications to utilize sidewalk or transit data for other routing and navigation purposes.	Demonstration	Medium

Source: University of Washington and Cambridge Systematics.

3.1.12. Data Provenance

Table 15 presents the system requirements related to the activities of documenting the various operations that occurred on data (data processing, data analysis, data transfer) to achieve reproducibility and citability.

Table 15. Transportation Data Equity Initiative data provenance functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-PV-01	Changes approved and committed to the data repository shall document and timestamp a new version.	Demonstration	High
F-PV-02	Change records shall be traceable to the agencies/organizations that perform data vetting.	Demonstration	Medium
F-PV-03	Change records shall be traceable to the agencies/organizations that respond to data vetting reports.	Demonstration	Medium
F-PV-04	Date stamps shall be present to ensure that the data are valid for specific dates and are not used past valid time periods.	Demonstration	High
F-PV-05	Two-way information sharing shall reference to the originator of the data.	Demonstration	Medium
F-PV-06	Changes shall be logged to help identify future events, such as planned route closures.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.1.13. Data Performance

No requirements focused on activities that involve data access optimization or other performance issues.

3.1.14. Data Backup

Table 16 presents the system requirements related to the activities that involve the management of physical risks to the data throughout the data lifecycle. Routine local backups are critical to prevent the physical loss of data prior to the final preservation of the data.

Table 16. Transportation Data Equity Initiative data backup functional requirements.

SyRS ID	Requirement	Verification Method	Priority
F-BA-01	Data stored in the data repository shall be backed up periodically so that in the event of a system issue (e.g., data loss, data corruption, application outage), failover will occur, and the data repository will remain available.	Inspection	Medium
F-BA-01.01	Backup methods used shall meet USDOT requirements for records retention.	Inspection	Medium
F-BA-01.02	Backup methods shall archive, at a minimum, each data contribution that is provided by a data contributor.	Inspection	Medium
F-BA-01.03	Research data collected as part of the ITS4US Program as well as production data shall be backed up.	Inspection	Medium
F-BA-02	Data back-ups shall be sent to an offsite location or a cloud service in the event of widespread damage to the proposed system's primary location.	Inspection	Medium
F-BA-03	Recovery of back-up data shall occur upon initiation of the restoration effort.	Test	Medium
F-BA-04	The TDEI system shall have an automatic failover system that transitions to the backup location when the system's primary location is not operational.	Inspection	Medium

Source: University of Washington and Cambridge Systematics.

3.1.15. Data Long Term Preservation

No requirements focused on activities associated with preserving data for long-term use, reuse, and accessibility.

3.2. Physical

This section describes the physical requirements of the system. Physical requirements have been categorized into construction, durability, adaptability, and environmental conditions.

3.2.1. Construction

Table 17 presents the system requirements on the physical location and design of the system, hardware, and infrastructure.

Table 17. Transportation Data Equity Initiative construction physical requirements.

SyRS ID	Requirement	Verification Method	Priority
P-CO-01	The TDEI system shall have its processing elements and data repository be stored in a networked central server environment.	Inspection	Medium
P-CO-02	The TDEI system shall provide network connections to the data collection tools from many physical locations.	Test	High
P-CO-03	The TDEI system shall provide network connections to the data translation tools from many physical locations.	Test	High
P-CO-04	The TDEI system shall provide network connections to the data vetting tools from many physical locations.	Test	High
P-CO-05	Data collection tools shall operate on standard office computer hardware or standard mobile tablet devices.	Test	High
P-CO-06	Data translation tools shall operate on standard office computer hardware or standard mobile tablet devices.	Test	High
P-CO-07	Data vetting tools shall operate on standard office computer hardware or standard mobile tablet devices.	Test	High
P-CO-08	The TDEI system's demonstration applications shall operate on standard Internet browsers or mobile devices (Android, iOS).	Test	High
P-CO-09	The TDEI system and all associated components shall send data successfully over landline or wireless Internet without priority or special accommodation (e.g., virtual private networks [VPN]).	Test	High

Source: University of Washington and Cambridge Systematics.

3.2.2. Durability

Table 18 presents the system requirements related to the durability of the system (what conditions it must be able to withstand).

Table 18. Transportation Data Equity Initiative durability physical requirements.

SyRS ID	Requirement	Verification Method	Priority
P-DU-01	The TDEI system's processing elements shall be able to accommodate multiple data contributors providing sidewalk and/or transit-related data submissions simultaneously.	Analysis	High
P-DU-02	The TDEI system's processing elements shall be able to accommodate multiple applications and application account users requesting sidewalk and/or transit-related data submissions simultaneously.	Analysis	High
P-DU-03	The TDEI system's data translation tools shall accommodate sidewalk and/or transit data contributions.	Analysis	High
P-DU-04	The TDEI system's demonstration applications shall:	Test	High
P-DU-04.01	Request relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.	Test	High
P-DU-04.02	Receive relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.	Test	High
P-DU-04.03	Present relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.	Test	High
P-DU-05	The TDEI system and all affiliated tools shall be capable of operating in isolation from other components with reductions in features.	Analysis	Medium

Source: University of Washington and Cambridge Systematics.

3.2.3. Adaptability

Table 19 presents the system requirements related to growth, expansion, contraction, or other adaptations the system must be able to handle. Many of these requirements deal with how the system will continue operation in the future as new technology is introduced, standards evolve, or other changes arise.

Table 19. Transportation Data Equity Initiative adaptability physical requirements.

SyRS ID	Requirement	Verification Method	Priority
P-AD-01	The TDEI system and all affiliated tools shall accommodate scalable information increases as new data is added to the system.	Analysis	High

Source: University of Washington and Cambridge Systematics.

3.2.4. Environmental Conditions

Table 20 presents the system requirements related to environmental conditions in which the system must operate.

Table 20. Transportation Data Equity Initiative environmental condition physical requirements.

SyRS ID	Requirement	Verification Method	Priority
P-EN-01	The TDEI system's processing components shall operate without degradation in typical server environments.	Analysis	High
P-EN-02	The TDEI system's data translation tools shall operate without degradation in environments approved for consumer personal computers (PC) and mobile devices.	Analysis	High
P-EN-03	The TDEI system's data demonstration applications shall operate without degradation in environments approved for consumer PCs and mobile devices.	Analysis	High
P-EN-04	The TDEI system's data demonstration applications shall operate with full capabilities to the end user without disruption from ambient background noise common in their travel environment (e.g., sidewalks near traffic, etc.).	Analysis	High

Source: University of Washington and Cambridge Systematics.

3.3. System Performance Characteristics

Table 21 presents the system requirements that define the quantitative performance characteristics that the system shall meet to fulfill the user needs.

Table 21. Transportation Data Equity Initiative system performance characteristic requirements.

SyRS ID	Requirement	Verification Method	Priority
PER-01	The TDEI system shall be perceived as reliable by end users (e.g., with minimal system freezes, crashes and failures).	Analysis	High
PER-02	The TDEI system shall adhere to the following system performance targets:	Analysis	High
PER-02.01	The TDEI system comprehensively shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.02	The TDEI system's data collection tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.03	The TDEI system's data translation tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.04	The TDEI system's data vetting tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.05	The TDEI system shall allow for data vetting to occur in a timely manner that keeps data current.	Analysis	High
PER-02.06	Data upload transactions to the TDEI system's data repository shall occur without errors 99 percent of the time.	Analysis	High
PER-02.07	The TDEI system's processing and data repository components shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.08	The TDEI system's data services shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.09	The TDEI system shall fulfill application developers' data requests and provide approved information within 15 seconds of a query.	Test	High

SyRS ID	Requirement	Verification Method	Priority
PER-02.10	The TDEI system's demonstration applications shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.	Analysis	High
PER-02.11	The TDEI system's demonstration applications shall fulfill users' data requests and provide information within 15 seconds of a query.	Test	High
PER-03	The TDEI system shall support performance tracking.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.4. System Security and Privacy

Table 22 presents the system requirements for both the cyber and physical security of the system, particularly dealing with protection from external actors. Protecting PII is a top priority, especially for the Complete Trip—ITS4US Program.

Table 22. Transportation Data Equity Initiative system security and privacy requirements.

SyRS ID	Requirement	Verification Method	Priority
SEC-01	The TDEI system shall include user permissions that ensure the safe and secure transmission of data and metadata.	Inspection	High
SEC-02	The TDEI system shall include procedures that ensure the safe and secure transmission of data and metadata.	Inspection	High
SEC-03	The TDEI system shall require permission from end users for use of data that may be considered Locational PII prior to data being collected.	Demonstration	High
SEC-04	The TDEI system shall protect user privacy to the extent possible.	Inspection	High
SEC-05	The TDEI system shall ensure that the information technology (IT) policies and safeguards are consistently up to date to reduce unauthorized access to routing request data.	Inspection	High
SEC-06	The TDEI system shall introduce intermediary layers to secure communications with the interoperable data infrastructure and storage.	Inspection	High

SyRS ID	Requirement	Verification Method	Priority
SEC-07	The TDEI system shall include an audit/reporting system that routinely scans for security risks.	Inspection	High
SEC-08	The system design of the central database shall include redundancy and encrypted data archiving to ensure the continued operation of the system if major failures of or attacks on the system occur.	Inspection	High
SEC-09	The TDEI system shall utilize National Institute of Standards and Technology (NIST) SP800-53, Recommended Security Controls for Federal Information Systems and Organizations for guidance to manage system safety risks.	Inspection	High

Source: University of Washington and Cambridge Systematics.

3.5. Information Management

Table 23 presents the system requirements to protect and manage information and data within the system. This section includes requirements within the system to manage user privacy and data such as passwords, encryption, access levels, etc.

Table 23. Transportation Data Equity Initiative information management requirements.

SyRS ID	Requirement	Verification Method	Priority
MAN-01	The TDEI system shall encrypt all system communications that travel over public data links.	Demonstration	High
MAN-02	The TDEI system shall contain different access levels (e.g., open and private), with defined user roles, to prevent unauthorized access of data and provide protection for sensitive private data.	Inspection	High
MAN-03	The TDEI system's demonstration applications shall not share user account information with the processing or data repository components.	Demonstration	High
MAN-04	The TDEI system shall version-control updates made to the sidewalk graph network and transit data that is stored in the data repository.	Demonstration	High
MAN-05	The TDEI system shall only distribute the latest approved version of sidewalk data when requested.	Demonstration	High

SyRS ID	Requirement	Verification Method	Priority
MAN-06	The TDEI system shall only distribute the latest approved version of transit data when requested.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.6. System Operations

This section describes the requirements related to system operations. System operations requirements have been categorized into system human factors, system maintainability, and system reliability.

3.6.1. System Human Factors

Table 24 presents the system requirements pertaining to all interactions between the user and the system, as well as other critical attributes of the system to serve the underserved communities and users. These requirements are particularly important for the ITS4US Program as the TDEI deployment will need to accommodate users of varying abilities.

Table 24. Transportation Data Equity Initiative system human factor requirements.

SyRS ID	Requirement	Verification Method	Priority
S-HF-01	The TDEI system's data vetting tools shall have a user interface that is easily understood by target user groups.	Inspection	High
S-HF-02	The TDEI system's data vetting tools shall include clearly understood instructions for vetting data.	Inspection	High
S-HF-03	The TDEI system's data vetting tools shall minimize the number of entries for user input, as required.	Inspection	High
S-HF-04	The TDEI system's data vetting tools shall allow the reviewer to request changes to the published data.	Inspection	High
S-HF-05	The TDEI system's data vetting tools shall allow the originator of the data to approve or reject changes proposed by other system participants.	Inspection	High
S-HF-06	The TDEI system's demonstration applications shall:	Inspection	High

SyRS ID	Requirement	Verification Method	Priority
S-HF-06.01	Communicate route and navigation information to an end user in a manner that is interpreted by the application's targeted user group (e.g., using iOS or Android "accessibility" tags that are utilized by many population groups).	Inspection	Medium
S-HF-06.02	Interface with an end user using communication methods that are understood by the user (e.g., haptic feedback, text-to-speech, etc.) for providing information, based on that application's target user group.	Inspection	High
S-HF-06.03	Have inputs (for origin, destination, trip-specific travel preferences) and instructions for path routing applications that are understood by the user.	Inspection	High
S-HF-06.04	Provide explanations that are understood by the user of local environmental attributes for spontaneous travel information applications.	Inspection	High
S-HF-06.05	Provide explanations that are understood by the user of local built environment attributes for digital twin applications.	Inspection	High
S-HF-06.06	Provide users with the ability to provide input or corrections to sidewalk data.	Inspection	Medium
S-HF-06.07	Provide users with the ability to provide input or corrections to transit data.	Inspection	Medium

Source: University of Washington and Cambridge Systematics.

3.6.2. System Maintainability

Table 25 presents the system requirements on the quantitative requirements regarding maintenance activities and support of the system.

Table 25. Transportation Data Equity Initiative system maintainability requirements.

SyRS ID	Requirement	Verification Method	Priority
S-MN-01	The TDEI system and associated tools shall have a defined preventative maintenance program to check for issues.	Inspection	Medium
S-MN-02	The TDEI system's demonstration applications should conduct regular preventative maintenance to detect and resolve any issues.	Demonstration	High
S-MN-03	The TDEI system's demonstration applications should have a mechanism for user reporting of application errors.	Inspection	Medium
S-MN-04	The TDEI system shall have a maintenance log to identify when issues are reported and when they are corrected.	Demonstration	Medium

Source: University of Washington and Cambridge Systematics.

3.6.3. System Reliability

Table 26 presents the system requirements related to the modes of operation defined in the ConOps and how the system maintains reliability and safeguards. These requirements include quantitative reliability requirements and the conditions under which the requirements are to be met.

Table 26. Transportation Data Equity Initiative system reliability requirements.

SyRS ID	Requirement	Verification Method	Priority
S-RL-01	The TDEI system shall operate in the normal mode of operation in order to be considered fully operational.	Demonstration	High
S-RL-02	The TDEI system shall automatically notify relevant maintenance staff in the event that the mode of operation is in a disrupted mode.	Demonstration	High
S-RL-03	The TDEI system shall automatically notify relevant maintenance staff in the event that the mode of operation is in a degraded mode.	Demonstration	High
S-RL-04	The TDEI system shall automatically notify relevant maintenance staff in the event that the mode of operation is in a failed mode.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.7. Policy and Regulation

Table 27 presents the system requirements related to organizational policies, external regulatory requirements, or constraints that may impact the operation or use of the system. These requirements detail how the system plans to meet the operational policies described in the ConOps and summarized in **Section 2.4.3**.

Table 27. Transportation Data Equity Initiative policy and regulation requirements.

SyRS ID	Requirement	Verification Method	Priority
POL-01	The TDEI system shall include policies that allow sharing of the collected data.	Inspection	High
POL-01.01	System-specific cybersecurity policies shall be implemented to protect restricted datasets from unauthorized access.	Inspection	High
POL-02	The TDEI system shall publish route information that is understood by the user to be "for information only," with no guarantee or expectation that the supporting data is accurate.	Inspection	Medium
POL-03	Any PII data collected by a demonstration application shall not be shared with the data repository.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

3.8. System Lifecycle Sustainment

Table 28 presents the system requirements related to any quality control and assurance activities, such as review, and measurement collection and analysis, to help realize a quality system. Over time, new technology, user needs, and ideas will arise as the system moves through the lifecycle. Data needs to be captured and analyzed to determine what impact possible enhancements will have on the system engineering process and the system.

Table 28. Transportation Data Equity Initiative system lifecycle sustainment requirements.

SyRS ID	Requirement	Verification Method	Priority
LIF-01	The TDEI system and associated tools shall have the capability to remain functional during the duration of the ITS4US project.	Inspection	High
LIF-02	The TDEI system and associated tools shall not be restricted from being adopted and incorporated into another data service provider's program.	Inspection	High
LIF-03	The TDEI system shall be capable of accommodating updated data flows as data schemas or standards change.	Test	High

Source: University of Washington and Cambridge Systematics.

4. System Interfaces

This section includes requirements for internal and external system interfaces. They have been developed based on the user needs and operational scenarios, as presented in the ConOps, as well as the DMP, SMP, and PMESP.

For each requirement, the following information is provided:

- **SyRS ID**—A unique ID by which to identify the system requirement.
- **Requirement**—Description of the requirement that fulfills part of, or a complete User Need as documented in the ConOps.
- **Verification Method**—Method used to verify each requirement. The recommended verification methods are as follows:
 - **Analysis**—This method describes the use of analytical data, analysis, or simulations under defined conditions to show theoretical compliance and is used where testing to realistic conditions cannot be achieved or is not cost effective. Analysis (including simulation or simple logical conclusion) may be used when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution.
 - **Demonstration**—This method uses a set of test activities with system stimuli (actual or simulated) selected by the system developer that may be used to show that system or subsystem response to stimuli is suitable. This is the primary method to test functional capability.
 - **Inspection**—This method describes an examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation (e.g., platform compliance).
 - **Test**—This method describes an action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated.
- **Priority Level**—Classifies each requirement as high, medium, or low. The definition for each of these levels are as follows:
 - **High**—Requirements are deemed essential for the new system.
 - **Medium**—Requirements are deemed desirable for the new system.
 - **Low**—Requirements are deemed optional for the new system.

Refer to **Appendix B** for the user needs-to-system requirements traceability matrix.

4.1. Internal System Interfaces

Table 29 presents the system requirements related to interdependencies, communication protocols, communication standards, and communication formats of internal system components. This may include interfaces between hardware, the system and operators or the system and users.

Table 29. Transportation Data Equity Initiative internal system interface requirements.

SyRS ID	Requirement	Verification Method	Priority
INT-01	The TDEI system shall move sidewalk data from the sidewalk data collectors to the sidewalk data processing components.	Demonstration	High
INT-02	The TDEI system shall move transit data from the transit data collectors to the transit data processing components.	Demonstration	High
INT-03	The TDEI system shall move data from the data processing components to the data repository.	Demonstration	Medium
INT-04	The data repository shall move sidewalk data to the sidewalk data service components.	Demonstration	Medium
INT-05	The data repository shall move transit data to the transit data service components.	Demonstration	Medium
INT-06	TDEI system shall use software toolsets to input observations into translated data.	Demonstration	High
INT-07	The TDEI system shall use software applications to interface between the data and the end user.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

4.2. External System Interfaces

Table 30 presents the system requirements related to interdependencies, communication protocols, communication standards, and communication formats as the system interfaces with other external systems.

Table 30. Transportation Data Equity Initiative external system interface requirements.

SyRS ID	Requirement	Verification Method	Priority
EXT-01	The TDEI system shall pass data to approved third-party applications.	Demonstration	High
EXT-02	The TDEI system shall pass data to an USDOT-managed system.	Demonstration	High

Source: University of Washington and Cambridge Systematics.

Appendix A. Definitions, Acronyms, and Abbreviations

Acronym	Definition
AD	Application developer
API	application program interface
Civic Technology	Technology that enhances the relationship between people and Government, such as software for communications, decisionmaking, service delivery, or that enables engagement in the political process.
ConOps	Concept of Operations
CSV	Comma Separated Values
DG	Data generators
DMP	Data Management Plan
DS	Data service provider
DU	Digital device end user experiencing travel barriers
FHWA	Federal Highway Administration
GTFS	General Transit Feed Specification
GTFS-Flex	The Flex route extension to the General Transit Feed Specification, designed to describe demand-responsive or paratransit service
GTFS-Pathways	The Pathways extension to the General Transit Feed Specification which defines pathways linking together locations within stations
iOS	iPhone Operating System
IT	Information technology
ITS	Intelligent transportation system
ITS JPO	Intelligent Transportation Systems Joint Programs Office
JSON	JavaScript Object Notation
LiDAR	light detection and ranging
NIST	National Institute of Standards and Technology
NRTM	Needs-to-Requirements Matrix
PC	personal computer
PMESP	Performance Measurement and Evaluation Support Plan
SMP	Safety Management Plan
SyRS	System Requirements Specification
Taskar Center or TCAT	Taskar Center for Accessible Technology at the University of Washington
TDEI	Transportation Data Equity Initiative
TSP	Transportation service provider
U.S.	United States
USDOT	United States Department of Transportation
UW	University of Washington
VA	Veterans Affairs
VPN	Virtual Private Network
XML	Extensible markup language

Appendix B. Needs-to-Requirements Traceability Matrix

Table 31 presents the TDEI Needs-to-Requirements Matrix (NRTM), which tracks traceability between requirements and the user needs introduced in the ConOps. This traceability will form the basis of the traceability to design, test cases, and test procedures as the system engineering process continues. The NTRM traceability will be maintained through the entire process as it is the first link from the user needs into the details of the system. Without this traceability, it becomes impossible to determine if the system fulfills the user needs when complete.

Table 31. Transportation Data Equity Initiative needs-to-requirements traceability matrix.

User Need/ Requirement ID	Need/Requirement Text
UN-DG1	DGs need data collection techniques that produce routable pathway networks that describe the path infrastructure in objective, neutral detail and include detailed pathway locations, connectivity, features, and characteristics.
F-CO-02	The built environment features received by the TDEI system shall adhere to the following:
F-CO-02.02	The built environment features shall be able to support nongraphic representation.
F-CO-03	The TDEI system shall provide data translation tools.
F-CO-03.01	The TDEI system shall provide tools for sidewalk data producers to translate existing sidewalk data into the OpenSidewalks data format.
F-CO-04	The TDEI system shall provide data collection tools.
F-CO-04.02	The data collection tools shall include automated sidewalk data collection technologies (e.g., advanced analytics used by mapping technology companies) to populate sidewalk databases.
F-PR-09	The TDEI system shall facilitate the processing of data into routable pathways networks.
F-PR-09.01	The routable pathway networks shall objectively describe the path infrastructure.
F-PR-09.02	The routable pathway networks shall include pathway locations.

User Need/ Requirement ID	Need/Requirement Text
F-PR-09.03	The routable pathway networks shall include pathway connectivity.
F-PR-09.04	The routable pathway networks shall include pathway features.
F-PR-09.05	The routable pathway networks shall include pathway characteristics.
F-PR-09.08	The TDEI system shall augment relevant links where connectivity exists.
UN-DG2	DGs need access to a common, sustainable process for uploading data and metadata, including data provenance features, to shared data repositories.
F-CO-01	The TDEI system shall be capable of receiving data from multiple sources.
F-CO-01.01	The TDEI system shall be capable of receiving sidewalk data from data generators.
F-CO-05	The TDEI system shall provide formal processes for uploading data and metadata.
F-PR-01	The TDEI system shall develop the data processing components that accept submitted data.
P-CO-02	The TDEI system shall provide network connections to the data collection tools from many physical locations.
P-CO-03	The TDEI system shall provide network connections to the data translation tools from many physical locations.
P-CO-04	The TDEI system shall provide network connections to the data vetting tools from many physical locations.
P-CO-05	The TDEI system shall provide network connections to the data collection tools from many physical locations.
P-CO-06	The TDEI system shall provide network connections to the data translation tools from many physical locations.
P-CO-07	The TDEI system shall provide network connections to the data vetting tools from many physical locations.
P-CO-09	The TDEI system and all associated components shall send data successfully over landline or wireless Internet without priority or special accommodation (e.g., VPNs).

User Need/ Requirement ID	Need/Requirement Text
P-DU-01	The TDEI system's processing elements shall be able to accommodate multiple data contributors providing sidewalk and/or transit-related data submissions simultaneously.
P-DU-03	The TDEI system's data translation tools shall accommodate sidewalk and/or transit data contributions.
P-EN-02	The TDEI system's data translation tools shall operate without degradation in environments approved for consumer PCs and mobile devices.
PER-02	The TDEI system shall adhere to the following system performance targets:
PER-02.01	The TDEI system comprehensively shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.02	The TDEI system's data collection tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.03	The TDEI system's data translation tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.04	The TDEI system's data vetting tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.05	The TDEI system shall allow for data vetting to occur in a timely manner that keeps data current.
PER-02.06	Data upload transactions to the TDEI system's data repository shall occur without errors 99 percent of the time.
SEC-01	The TDEI system shall include user permissions that ensure the safe and secure transmission of data and metadata.
SEC-02	The TDEI system shall include procedures that ensure the safe and secure transmission of data and metadata.
LIF-01	The TDEI system and associated tools shall have the capability to remain functional during the duration of the ITS4US project.
UN-DG3	DGs need clear, unambiguous guidance/guidelines on generating data, including data standard specifications, schemas, and coding instructions.
F-DE-03	The TDEI system shall provide guidance/guidelines for its participants that is easily understood without the need for specialized training.

User Need/ Requirement ID	Need/Requirement Text
F-DE-03.01	Guidance/guidelines shall be provided through data standard specifications.
F-DE-03.02	Guidance/guidelines shall be provided through data standard schemas.
F-DE-03.03	Guidance/guidelines shall be provided through coding instructions.
F-DE-03.04	Guidance/guidelines shall cover generating data in approved formats.
F-DE-08	Data standard schemas shall be made available to data generators.
F-CO-04	The TDEI system shall provide data collection tools.
F-CO-04.01	The data collection tools shall convert data into compatible or conflatable to the refined data standards for OpenSidewalks, GTFS data format or, where applicable, a comparable extension.
LIF-03	The TDEI system shall be capable of accommodating updated data flows as data schemas or standards change.
UN-DG4	DGs need data standard specifications that are published, version-tracked, vetted, and include governance provisions that allow for effective management of data updates and revisions.
F-DE-04	Data standard specifications shall be publicly available.
F-DE-04.02	Data standard specifications shall be published.
F-DE-04.03	Data standard specifications shall be version-tracked.
F-DE-04.04	Data standard specifications shall be vetted.
F-DE-04.07	Data standard specifications shall include governance provisions that allow for effective management of data updates and revisions.
F-EX-01	Updates to the data schema structure shall follow a formal update process.
F-EX-02	Notifications shall be provided to approved TDEI system users when data schema updates occur.
F-EX-03	Data standards used in the TDEI system shall be open sourced.
F-UP-01	The data repository shall support continuous updates.
F-PV-01	Changes approved and committed to the data repository shall document and timestamp a new version.

User Need/ Requirement ID	Need/Requirement Text
MAN-04	The TDEI system shall version-control updates made to the sidewalk graph network and transit data that is stored in the data repository.
MAN-05	The TDEI system shall only distribute the latest approved version of sidewalk data when requested.
MAN-06	The TDEI system shall only distribute the latest approved version of transit data when requested.
UN-DG4a	DGs need data standard examples.
F-DE-04.01	Data standard specifications shall include OpenSidewalks, GTFS-Flex, and GTFS-Pathways.
UN-DG4b	DGs need each data standard element and attribute to have specified allowable values and error tolerance levels, where applicable.
F-DE-04.08	Data standard specifications shall include specified allowable values and error tolerance levels for data standard elements and attributes, where applicable.
UN-DG5	DGs need each data standard schema to include information about the database structure and database metadata according to agreed models and schemas, and to use standard classifications and vocabularies.
F-DE-04.06	Data standard specifications shall contain standardized metadata.
F-DE-04.06.03	Metadata shall describe the data standards and structure.
F-DE-08.01	Data standard schemas shall include information about the database structure and database metadata.
F-DE-08.02	Data standard schemas shall use standard classifications and vocabularies for defining attributes and specifications.
LIF-03	The TDEI system shall be capable of accommodating updated data flows as data schemas or standards change.
UN-DG6	System participants, including both users (ADs) and producers (DGs), need a common definition of data regarding the meaning of the terms used to describe data contents and proper usage of the data.
F-DE-04	Data standard specifications shall be publicly available.
F-DE-04.01	Data standard specifications shall include OpenSidewalks, GTFS-Flex, and GTFS-Pathways.

User Need/ Requirement ID	Need/Requirement Text
F-DE-04.05	Data standard specifications shall include a data dictionary.
UN-DG7	DGs need consistent information models and accepted terminologies/coding systems, which provide the semantic foundation for the sharing of information. Key to this sharing is the ability to not only share labels, but to maintain consistency of meaning, particularly across organizations or national boundaries.
F-QC-03	The TDEI system shall include the development of validation toolsets for assembling sidewalk and transit environment data from multiple providers.
UN-DG8	DGs need tools to vet the data they generate to ensure the data conform to standards and are of consistent, acceptable quality.
F-DE-03.01	Guidance/guidelines shall be provided through data standard specifications.
F-DE-03.05	Guidance/guidelines shall cover quality assurance requirements of the data.
F-CO-01.06	The TDEI system shall be capable of receiving data from crowdsourced applications to enable private citizens to identify needed local map updates and vet data submitted by others.
F-PR-05	The TDEI system shall support processes for vetting the data.
F-QC-01	The TDEI system shall require a data vetting process for all data before they are deposited into the core data repository to identify invalid data that have been reported.
F-QC-02	The TDEI system shall provide access to data vetting tools.
F-QC-02.01	The data vetting tools shall confirm whether the data conform to standards.
F-QC-02.02	The data vetting tools shall confirm whether the data are of sufficient accuracy.
F-QC-02.03	The data vetting tools shall confirm whether the data are of consistent quality.
F-QC-02.04	The data vetting tools shall describe when data are missing.
F-QC-02.05	The data vetting tools shall support automated data vetting activities (e.g., automated data review to check for data format and permissible data).
F-QC-02.06	The data vetting tools shall support manual data vetting activities (e.g., owner/hired consultant review, community/organization reviews, traveler feedback).

User Need/ Requirement ID	Need/Requirement Text
S-HF-01	The TDEI system's data vetting tools shall have a user interface that is easily understood by target user groups.
S-HF-02	The TDEI system's data vetting tools shall include clearly understood instructions for vetting data.
S-HF-03	The TDEI system's data vetting tools shall minimize the number of entries for user input, as required.
S-HF-04	The TDEI system's data vetting tools shall allow the reviewer to request changes to the published data.
S-HF-05	The TDEI system's data vetting tools shall allow the originator of the data to approve or reject changes proposed by other system participants.
UN-TS1	TSS need to be able to publish consistent, standardized, digital data describing the services they provide and the travel environments they manage.
F-CO-01	The TDEI system shall be capable of receiving data from multiple sources.
F-CO-01.03	The TDEI system shall be capable of receiving fixed-route transit data from transportation service providers.
F-CO-01.04	The TDEI system shall be capable of receiving on-demand transit data from transportation service providers.
F-CO-01.05	The TDEI system shall be capable of receiving transit station layout data from transportation service providers.
F-CO-03	The TDEI system shall provide data translation tools.
F-CO-03.02	The TDEI system shall provide tools for transit data producers to translate existing fixed-route data into the GTFS data format and associated extensions.
F-CO-03.03	The TDEI system shall provide tools for transit data producers to translate existing on-demand data into the GTFS data format and associated extensions.
F-CO-03.04	The TDEI system shall provide tools for transit data producers to translate existing transit station data into the GTFS data format and associated extensions.
F-CO-05	The TDEI system shall provide formal processes for uploading data and metadata.

User Need/ Requirement ID	Need/Requirement Text
F-PR-01	The TDEI system shall develop the data processing components that accept submitted data.
F-SH-01	The TDEI system shall include data provisioning services that distribute data-on-demand for use in a variety of applications.
F-SH-01.01	Data that is shared through the TDEI system shall be published on a Web service, either open to the public or through a requested API service.
P-CO-02	The TDEI system shall provide network connections to the data collection tools from many physical locations.
P-CO-03	The TDEI system shall provide network connections to the data translation tools from many physical locations.
P-CO-04	The TDEI system shall provide network connections to the data vetting tools from many physical locations.
P-CO-05	Data collection tools shall operate on standard office computer hardware or standard mobile tablet devices.
P-CO-06	Data translation tools shall operate on standard office computer hardware or standard mobile tablet devices.
P-CO-07	Data vetting tools shall operate on standard office computer hardware or standard mobile tablet devices.
P-CO-09	The TDEI system and all associated components shall send data successfully over landline or wireless Internet without priority or special accommodation (e.g., VPNs).
P-DU-01	The TDEI system's processing elements shall be able to accommodate multiple data contributors providing sidewalk and/or transit-related data submissions simultaneously.
P-DU-03	The TDEI system's data translation tools shall accommodate sidewalk and/or transit data contributions.
P-EN-02	The TDEI system's data translation tools shall operate without degradation in environments approved for consumer PCs and mobile devices.
PER-02	The TDEI system shall adhere to the following system performance targets:
PER-02.01	The TDEI system comprehensively shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.

User Need/ Requirement ID	Need/Requirement Text
PER-02.02	The TDEI system's data collection tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.03	The TDEI system's data translation tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.04	The TDEI system's data vetting tools shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.05	The TDEI system shall allow for data vetting to occur in a timely manner that keeps data current.
PER-02.06	Data upload transactions to the TDEI system's data repository shall occur without errors 99 percent of the time.
SEC-01	The TDEI system shall include user permissions that ensure the safe and secure transmission of data and metadata.
SEC-02	The TDEI system shall include procedures that ensure the safe and secure transmission of data and metadata.
INT-02	The TDEI system shall move transit data from the transit data collectors to the transit data processing components.
INT-06	TDEI system shall use software toolsets to input observations into translated data.
UN-TS2	TSs need to have an effective common data approach through which they can understand, analyze, visualize, and compare their ridership and service efficacy to those of other TSs.
F-DE-02	The TDEI system shall utilize a common data model.
UN-TS2a	TSs need a common data approach that is coordinated with other TSs.
F-CO-04	The TDEI system shall provide data collection tools.
F-CO-04.03	The data collection tools shall include technologies that help generate data that describe on-demand transportation services.
F-QC-03	The TDEI system shall include the development of validation toolsets for assembling sidewalk and transit environment data from multiple providers.
UN-TS2b	TSs need a common data approach that provides a common set of guidelines across agencies and governments.

User Need/ Requirement ID	Need/Requirement Text
F-DE-03	The TDEI system shall provide guidance/guidelines for its participants that is easily understood without the need for specialized training.
UN-TS3	TSs need to be able to take an organizational approach to data management that reflects and points to oversight and accountability models in order to use data commons effectively.
F-DE-04.07	Data standard specifications shall include governance provisions that allow for effective management of data updates and revisions.
UN-TS4	TSs need to be able to name body/bodies responsible for and having authority to publish transportation data.
SEC-01	The TDEI system shall include user permissions that ensure the safe and secure transmission of data and metadata.
MAN-02	The TDEI system shall contain different access levels (e.g., open and private), with defined user roles, to prevent unauthorized access of data and provide protection for sensitive private data.
UN-TS5	To operationalize transportation and transportation data services effectively, TSs need to be able to rely on a sustainable, properly governed data commons.
F-DE-04.07	Data standard specifications shall include governance provisions that allow for effective management of data updates and revisions.
LIF-01	The TDEI system and associated tools shall have the capability to remain functional during the duration of the ITS4US project.
LIF-03	The TDEI system shall be capable of accommodating updated data flows as data schemas or standards change.
UN-TS5a	The data commons needs to be comprehensive, timely, supported by metadata in conformity with appropriate standards.
F-DE-04.06	Data standard specifications shall contain standardized metadata.
F-DE-04.06.03	Metadata shall describe the data standards and structure.
UN-TS5b	The data contained in the commons needs to be released in multiple formats for different audiences and in compliance with any applicable laws and regulations.

User Need/ Requirement ID	Need/Requirement Text
F-DS-07	The TDEI system's demonstration applications shall support the delivery of information to users in different formats (audio, text, tactile displays, language) based on the intended audience of the demonstration application.
UN-TS6	TSs need to offer simple digital transportation data that simplify in-person transactions.
F-CO-03.02	The TDEI system shall provide tools for transit data producers to translate existing fixed-route data into the GTFS data format and associated extensions.
UN-TS7	TSs need to offer more and better inclusive travel options in urban areas.
F-DE-04.01	Data standard specifications shall include OpenSidewalks, GTFS-Flex, and GTFS-Pathways.
UN-TS8	TSs need to make their inclusive travel services easier to discover.
F-DE-04.01	Data standard specifications shall include OpenSidewalks, GTFS-Flex, and GTFS-Pathways.
UN-TS9	TSs to be able and willing to accept edits needed to their data.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.06	Provide users with the ability to provide input or corrections to sidewalk data.
S-HF-06.07	Provide users with the ability to provide input or corrections to transit data.
UN-DS1	DSs need to define and adhere to an approach to data governance with respect to open data about pedestrian paths, transportation environments, and on-demand travel services.
F-DE-04.07	Data standard specifications shall include governance provisions that allow for effective management of data updates and revisions.
UN-DS1a	Data governance needs to be a systemic, coordinated, and collaborative approach that offers good practice implementations and examples for handling data interoperability and integration issues from a data management perspective.
F-PR-07	The TDEI system shall support processes for managing the data.
S-MN-01	The TDEI system and associated tools shall have a defined preventative maintenance program to check for issues.

User Need/ Requirement ID	Need/Requirement Text
S-MN-04	The TDEI system shall have a maintenance log to identify when issues are reported and when they are corrected.
POL-01	The TDEI system shall include policies that allow sharing of the collected data.
POL-01.01	System-specific cybersecurity policies shall be implemented to protect restricted datasets from unauthorized access.
UN-DS2	DSs need a sustainable business model, including resulting performance measures, to keep interoperable data sharing repositories accessible.
F-SH-02	The TDEI system shall support interoperable sharing.
P-DU-01	The TDEI system's processing elements shall be able to accommodate multiple data contributors providing sidewalk and/or transit-related data submissions simultaneously.
S-MN-01	The TDEI system and associated tools shall have a defined preventative maintenance program to check for issues.
S-MN-02	The TDEI system's demonstration applications should conduct regular preventative maintenance to detect and resolve any issues.
S-MN-04	The TDEI system shall have a maintenance log to identify when issues are reported and when they are corrected.
UN-DS3	DSs need to identify cost effective ways to aggregate and distribute standardized data that describe the built environment, transportation service, and transportation infrastructure features from multiple agencies or jurisdictions.
F-PR-06	The TDEI system shall support processes for aggregating the data.
F-PR-08	The TDEI system shall support processes for fusing the data.
P-AD-01	The TDEI system and all affiliated tools shall accommodate scalable information increases as new data is added to the system.
UN-DS4	DSs need to adopt and agree on common data governance procedures, allowing interoperable sharing and data federation of standardized pathway feature and characteristic data, as well as transit service data and transit facility data.
F-ST-07	The data repository shall include transit station data.
F-SH-02	The TDEI system shall support interoperable sharing.

User Need/ Requirement ID	Need/Requirement Text
UN-DS5	DSs need to ensure that use of an interoperable data infrastructure will not increase the costs of using the technology (with the exception of marginal initial adoption costs), create difficulties in supporting accessible products, lengthen the time of development for end-user-facing applications, or serve only a small market.
F-SH-01	The TDEI system shall include data provisioning services that distribute data-on-demand for use in a variety of applications.
F-SH-01.02	Data that is shared through the TDEI system shall be accessible for different geographic locations.
UN-DS6	DSs need to ensure connectivity of features across different levels of transit stations (e.g., elevators, stairs).
F-PR-09	The TDEI system shall facilitate the processing of data into routable pathways networks.
F-PR-09.06	The routable pathway networks shall include connectivity of features across different levels of transit stations.
UN-DS6a	DSs need to ensure that data linkages exist when different transit agencies share a physical transit stop.
F-PR-09	The TDEI system shall facilitate the processing of data into routable pathways networks.
F-PR-09.07	The routable pathway networks shall ensure that data linkages exist when different transit agencies share a physical transit stop.
UN-DS7	DSs need to ensure that data remains fresh.
PER-02.05	The TDEI system shall allow for data vetting to occur in a timely manner that keeps data current.
UN-DS8	DSs need to support two-way information sharing, with reference to the originator of the data, to help ensure that the ecosystem of data is high quality.
F-DE-04.06.01	Metadata shall describe the origin of collected data.
F-CO-01	The TDEI system shall be capable of receiving data from multiple sources.
F-SH-03	The TDEI system shall support two-directional communication channels between the central database and the organizations that “own” the facility or service being described with data.

User Need/ Requirement ID	Need/Requirement Text
UN-AD1	ADs need data standard specifications to offer clear guidance/guidelines on accessing data, including how to access data and what data are being accessed.
F-DE-03	The TDEI system shall provide guidance/guidelines for its participants that is easily understood without the need for specialized training.
F-DE-03.01	Guidance/guidelines shall be provided through data standard specifications.
F-DE-03.06	Guidance/guidelines shall cover accessing data.
F-PR-02	The TDEI system shall process XML .osm files.
F-PR-03	The TDEI system shall process GTFS .csv files.
F-PR-04	The TDEI system shall process .json files, including GeoJSON data formats.
F-DI-01	The TDEI system shall use public-facing APIs to exchange data with application developers.
P-DU-02	The TDEI system's processing elements shall be able to accommodate multiple applications and application account users requesting sidewalk and/or transit-related data submissions simultaneously.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.01	Request relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
UN-AD1a	Data standard specifications need to be published, version-tracked, and vetted.
F-DE-04	Data standard specifications shall be publicly available.
F-DE-04.02	Data standard specifications shall be published.
F-DE-04.03	Data standard specifications shall be version-tracked.
F-DE-04.04	Data standard specifications shall be vetted.
F-CO-01.06	The TDEI system shall be capable of receiving data from crowdsourced applications to enable private citizens to identify needed local map updates and vet data submitted by others.
F-PV-01	Changes approved and committed to the data repository shall document and timestamp a new version.

User Need/ Requirement ID	Need/Requirement Text
F-PV-02	Change records shall be traceable to the agencies/organizations that perform data vetting.
F-PV-03	Change records shall be traceable to the agencies/organizations that respond to data vetting reports.
F-PV-04	Date stamps shall be present to ensure that the data are valid for specific dates and are not used past valid time periods.
F-PV-05	Two-way information sharing shall reference to the originator of the data.
F-PV-06	Changes shall be logged to help identify future events, such as planned route closures.
UN-AD1b	Data standard usage examples must be provided.
F-CO-04.01	The data collection tools shall convert data into compatible or conflatable to the refined data standards for OpenSidewalks, GTFS data format or, where applicable, a comparable extension.
UN-AD1c	Each data standard element and attribute needs to have specified allowable values and error tolerance levels, where applicable.
F-DE-04.08	Data standard specifications shall include specified allowable values and error tolerance levels for data standard elements and attributes, where applicable.
UN-AD2	ADs need data standards to specify attributes that support in-application interpretation of the available environment/service viz-a-viz the needs of the stakeholder population.
F-DE-01	Data standards shall use attributes that support travel preferences of travelers.
INT-07	The TDEI system shall use software applications to interface between the data and the end user.
UN-AD3	ADs need interoperable data that minimize the need for special design requirements when diversifying products geographically or to different user populations.
F-DE-05	Data standard specifications shall be scalable in different geographic markets or to different user populations.
F-DE-06	Data standard specifications shall be extensible in different geographic markets or to different user populations.

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F-DE-07	Data standard specifications shall be interoperable in different geographic markets or to different user populations.
F-DS-12	The TDEI system shall permit approved third-party mobile applications to utilize sidewalk or transit data for other routing and navigation purposes.
INT-03	The TDEI system shall move data from the data processing components to the data repository.
INT-04	The data repository shall move sidewalk data to the sidewalk data service components.
INT-05	The data repository shall move transit data to the transit data service components.
UN-AD4	ADs need access to standardized transactional data for on-demand transportation services or mode transfer options in order to integrate these travel options into navigation applications that enable all passengers to seamlessly complete trips involving two or more modes.
F-DE-01.03	Demand responsive travel services shall be described using the GTFS-Flex data standard, excluding real-time feeds.
F-ST-06	The data repository shall include on-demand transit data.
F-ST-09	The data repository shall include mode transfer options.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.03	Present relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
INT-07	The TDEI system shall use software applications to interface between the data and the end user.
UN-AD5	ADs need standard transportation service descriptions that establish a common understanding of service attributes.
F-CO-04.01	The data collection tools shall convert data into compatible or conflatable to the refined data standards for OpenSidewalks, GTFS data format or, where applicable, a comparable extension.
UN-AD6	ADs need access to detailed information regarding travel environments that connect mode transfers or trip segments in order to integrate these travel options into navigation applications.

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F-ST-10	The data repository shall include travel environments that connect mode transfers or trip segments.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.03	Present relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
INT-07	The TDEI system shall use software applications to interface between the data and the end user.
UN-AD7	ADs need a well-known and centralized governance body and community responsible for the facilitation of the continued discussion, development, and maintenance of data standards.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.03	Present relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.06	Provide users with the ability to provide input or corrections to sidewalk data.
S-HF-06.07	Provide users with the ability to provide input or corrections to transit data.
UN-AD8	ADs need sidewalk data to describe connections between nodes of the larger transportation network to allow navigation applications to determine routing segments that are critical to traversing some segments of many complete trips.
F-ST-08	The data repository shall include graphed sidewalk network data.
UN-AD9	ADs need pathway features and characteristics, transportation service, and transit station facility description data need to be compiled from reliable sources to ensure their accuracy and comprehensiveness.
F-DE-01.02	Transportation stations and hubs shall be described using the GTFS-Pathways data standard.
F-ST-01	The TDEI system shall include the creation of the centralized data repositories.
F-ST-02	The TDEI system shall include the operation of the centralized data repositories.
F-ST-03	The TDEI system shall include the maintenance of the centralized data repositories.

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F-ST-05	The data repository shall include fixed-route transit data.
F-BA-01	Data stored in the data repository shall be backed up periodically so that in the event of a system issue (e.g., data loss, data corruption, application outage), failover will occur, and the data repository will remain available.
F-BA-01.01	Backup methods used shall meet USDOT requirements for records retention.
F-BA-01.02	Backup methods shall archive, at a minimum, each data contribution that is provided by a data contributor.
F-BA-01.03	Research data collected as part of the ITS4US Program as well as production data shall be backed up.
F-BA-02	Data back-ups shall be sent to an offsite location or a cloud service in the event of widespread damage to the proposed system's primary location.
F-BA-03	Recovery of back-up data shall occur upon initiation of the restoration effort.
F-BA-04	The TDEI system shall have an automatic failover system that transitions to the backup location when the system's primary location is not operational.
P-CO-01	The TDEI system shall have its processing elements and data repository be stored in a networked central server environment.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.02	Receive relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
UN-AD10	ADs need pathway features and characteristics, transportation service, and transit station facility description data to be accessible in different geographical locations in order to improve the usability and scalability of end-user applications.
F-SH-01	The TDEI system shall include data provisioning services that distribute data-on-demand for use in a variety of applications.
F-SH-01.02	Data that is shared through the TDEI system shall be accessible for different geographic locations.
UN-AD10a	ADs need access to pathway features and characteristics data with standardized attributes.
F-DE-01.01	Pedestrian built environment shall be described using the OpenSidewalks data standard.

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F-CO-02	The built environment features received by the TDEI system shall adhere to the following:
F-CO-02.01	The built environment features shall be tagged correctly in the data schema.
F-DI-02	The OpenSidewalks data service shall receive the request from the application through its open secure API.
F-DI-03	The OpenSidewalks data service shall verify via the application's descriptive metadata.
F-DI-04	The OpenSidewalks data service shall request/query all relevant data from the data repository.
F-DI-05	The OpenSidewalks data service shall send all relevant data to the application that made the original request.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.02	Receive relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
UN-AD10b	ADs need data from multiple geographic locations and transit agencies in standardized formats.
F-DI-06	The GTFS data service shall perform the following functionality:
F-DI-06.01	Receive the request from the application through its open secure API.
F-DI-06.02	Verify via the application's descriptive metadata.
F-DI-06.03	Request/query all relevant data from the data repository.
F-DI-06.04	Send all relevant data to the application that made the original request.
P-DU-04	The TDEI system's demonstration applications shall:
P-DU-04.02	Receive relevant sidewalk and/or transit data to users that is relevant and prioritized for their trip needs.
UN-AD11	ADs need descriptors on the data provided in terms of collection date, confidence level, and completeness.
F-DE-04.06.02	Metadata shall indicate metrics for reviewers to determine the level of accuracy/completeness.

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F-QC-02	The TDEI system shall provide access to data vetting tools.
F-QC-02.07	The data vetting tools shall generate a degree of confidence associated with the data being published.
F-DS-06	The TDEI system's demonstration applications shall be designed to report data that is unavailable.
UN-AD12	ADs need to be able to understand and have confidence in the data governance policies for the data they will be accessing in order to have confidence in the data they are retrieving and using to describe pathway access features and characteristics, transportation services, and transit station facility descriptions. This includes having confidence that the data source contains vetted data and has policies and agreements in place to ensure that it is sustainable, reliable, and trusted over time.
F-PR-05	The TDEI system shall support processes for vetting the data.
F-ST-04	The TDEI system shall transmit approved data to centralized data repositories.
LIF-01	The TDEI system and associated tools shall have the capability to remain functional during the duration of the ITS4US project.
UN-AD13	ADs need to protect end user privacy by ensuring that interoperable transportation data sharing does not offer access to personal data, whether intentionally or unintentionally.
F-DS-11	The TDEI system shall safeguard PII data deemed necessary for operation.
SEC-04	The TDEI system shall protect user privacy to the extent possible.
SEC-05	The TDEI system shall ensure that IT policies and safeguards are consistently up to date to reduce unauthorized access to routing request data.
MAN-03	The TDEI system's demonstration applications shall not share user account information with the processing or data repository components.
POL-03	Any PII data collected by a demonstration application shall not be shared with the data repository.
UN-DU1	DUs need to be able to set boundaries on the allowed release of their personal data in order to gain functionality, while being protected from unapproved data releases.

User Need/ Requirement ID	Need/Requirement Text
F-DS-11	The TDEI system shall safeguard PII data deemed necessary for operation.
SEC-03	The TDEI system shall require permission from end users for use of data that may be considered Locational PII prior to data being collected.
MAN-01	The TDEI system shall encrypt all system communications that travel over public data links.
MAN-02	The TDEI system shall contain different access levels (e.g., open and private), with defined user roles, to prevent unauthorized access of data and provide protection for sensitive private data.
UN-DU2	DUs need accessible transportation data need to be clear, understandable, and interpretable when presented to a traveler without that individual requiring special knowledge or training.
F-CO-01.02	The TDEI system shall be capable of receiving external third-party data for relevant optional attributes, such as subjective path characteristics like presence of bushes.
F-DS-05	The TDEI system's demonstration applications shall use interfaces that minimize confusion for targeted user groups.
F-DS-05.01	The TDEI system's demonstration applications shall help the traveler identify when errors have occurred.
F-DS-05.02	The TDEI system's demonstration applications shall provide "help" functions that allow users to quickly obtain information about how to safely navigate from their current location.
F-DS-08	The TDEI system's demonstration applications shall provide information regarding transit service capabilities to help travelers avoid potential hazardous outcomes.
F-DS-10	The TDEI system's demonstration applications shall issue low-power warnings within the application.
P-CO-08	The TDEI system's demonstration applications shall operate on standard Internet browsers or mobile devices (Android, iOS).
P-CO-09	The TDEI system and all associated components shall send data successfully over landline or wireless Internet without priority or special accommodation (e.g., VPNs).

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P-EN-03	The TDEI system's data demonstration applications shall operate without degradation in environments approved for consumer PCs and mobile devices.
P-EN-04	The TDEI system's data demonstration applications shall operate with full capabilities to the end user without disruption from ambient background noise common in their travel environment (e.g., sidewalks near traffic, etc.).
PER-02	The TDEI system shall adhere to the following system performance targets:
PER-02.01	The TDEI system comprehensively shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.07	The TDEI system's processing and data repository components shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.08	The TDEI system's data services shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.09	The TDEI system shall fulfill application developers' data requests and provide approved information within 15 seconds of a query.
PER-02.10	The TDEI system's demonstration applications shall be operational 99.5 percent of the time 24 hours a day, 365 days per year.
PER-02.11	The TDEI system's demonstration applications shall fulfill users' data requests and provide information within 15 seconds of a query.
POL-02	The TDEI system shall publish route information that is understood by the user to be "for information only," with no guarantee or expectation that that the supporting data is accurate.
INT-01	The TDEI system shall move sidewalk data from the sidewalk data collectors to the sidewalk data processing components.
INT-06	TDEI system shall use software toolsets to input observations into translated data.
UN-DU3	DUs need access to accessible, integrated, and fluid travel information, including first- and last-mile options.
F-ST-11	The data repository shall include first- and last-mile options.
P-DU-02	The TDEI system's processing elements shall be able to accommodate multiple applications and application account users requesting sidewalk and/or transit-related data submissions simultaneously.

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P-EN-01	The TDEI system's processing components shall operate without degradation in typical server environments.
PER-03	The TDEI system shall support performance tracking.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.02	Interface with an end user using communication methods that are understood by the user (e.g., haptic feedback, text-to-speech, etc.) for providing information, based on that application's target user group.
S-HF-06.04	Provide explanations that are understood by the user of local environmental attributes for spontaneous travel information applications.
S-HF-06.05	Provide explanations that are understood by the user of local built environment attributes for digital twin applications.
EXT-01	The TDEI system shall pass data to approved third-party applications.
EXT-02	The TDEI system shall pass data to an USDOT-managed system.
UN-DU4	DUs need to be able to discover travel options with enough detail to make informed decisions on the best option to meet their unique mobility needs.
F-DS-05	The TDEI system's demonstration applications shall use interfaces that minimize confusion for targeted user groups.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.03	Have inputs (for origin, destination, trip-specific travel preferences) and instructions for path routing applications that are understood by the user.
S-RL-01	The TDEI system shall operate in the normal mode of operation in order to be considered fully operational.
S-RL-02	The TDEI system shall automatically notify relevant maintenance staff in the event that the mode of operation is in a disrupted mode.
S-RL-03	The TDEI system shall automatically notify relevant maintenance staff in the event that the mode of operation is in a degraded mode.
S-RL-04	The TDEI system shall automatically notify relevant maintenance staff in the event that the mode of operation is in a failed mode.

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UN-DU5	DUs need solutions that organize and declutter the transportation marketplace so that they do not need to use multiple different applications to determine travel options, which meet their individual needs across multiple travel environments and services.
F-DE-05	Data standard specifications shall be scalable in different geographic markets or to different user populations.
F-DE-06	Data standard specifications shall be extensible in different geographic markets or to different user populations.
F-DE-07	Data standard specifications shall be interoperable in different geographic markets or to different user populations.
F-SH-01	The TDEI system shall include data provisioning services that distribute data-on-demand for use in a variety of applications.
F-SH-01.02	Data that is shared through the TDEI system shall be accessible for different geographic locations.
F-DS-05	The TDEI system's demonstration applications shall use interfaces that minimize confusion for targeted user groups.
LIF-02	The TDEI system and associated tools shall not be restricted from being adopted and incorporated into another data service provider's program.
UN-DU6	DUs need traveler information to be presented in a way that does not expose the user's private data.
SEC-04	The TDEI system shall protect user privacy to the extent possible.
SEC-05	The TDEI system shall ensure that IT policies and safeguards are consistently up to date to reduce unauthorized access to routing request data.
UN-DU7	DUs need access to customizable information regarding travel environments, including multilevel and indoor environments, which connect them to or from their vehicle boarding locations, or that facilitate mode transfers or trip segments in order to ensure that any specific accessibility preferences can be met.
F-ST-09	The data repository shall include mode transfer options.
F-ST-10	The data repository shall include travel environments that connect mode transfers or trip segments.

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UN-DU8	Stakeholder populations with accessibility preferences need access to transportation network data that is objective and interpretable in order to self-determine whether the physical infrastructure is accessible to them.
F-DE-01	Data standards shall use attributes that support travel preferences of travelers.
F-CO-02	The built environment features received by the TDEI system shall adhere to the following:
F-CO-02.03	The built environment features shall be described in such a way that digital device end users can indicate their preferences without requiring additional explanation or training.
F-DS-09	The TDEI system's demonstration applications shall provide insight on areas where data quality is reported to be poor to help travelers make informed decisions.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.02	Interface with an end user using communication methods that are understood by the user (e.g., haptic feedback, text-to-speech, etc.) for providing information, based on that application's target user group.
S-HF-06.04	Provide explanations that are understood by the user of local environmental attributes for spontaneous travel information applications.
S-HF-06.05	Provide explanations that are understood by the user of local built environment attributes for digital twin applications.
POL-02	The TDEI system shall publish route information that is understood by the user to be "for information only," with no guarantee or expectation that the supporting data is accurate.
UN-DU9	Stakeholder populations with accessibility preferences need access to personalized travel planning and information services that are timely, accurate, and available either pretrip or en-route that can recommend comprehensive "best" paths as a function of each individual's travel preferences.
F-DS-01	The demonstration applications shall utilize the data returned by the TDEI data services to identify paths using the most up-to-date sidewalk and/or transit data (including any paths that involve a sidewalk path option or transit option, if requested or available).

User Need/ Requirement ID	Need/Requirement Text
F-DS-02	The demonstration applications shall utilize the data returned by the TDEI data services to screen those paths based on the user's trip-specific travel preferences.
F-DS-03	The demonstration applications shall utilize the data returned by the TDEI data services to provide one or more recommended routes, when such a route exists, to the end user.
F-DS-04	The TDEI system shall support the development of tools to make informed, customized travel decisions.
F-DS-04.01	The TDEI system shall utilize mobile applications to demonstrate the system by providing a sidewalk route based on user-defined travel preferences.
F-DS-04.02	The TDEI system shall utilize mobile applications to demonstrate the system by providing paths through transit stations based on user-defined travel preferences.
F-DS-04.03	The TDEI system shall utilize mobile applications to demonstrate the system by providing on-demand transit options based on user-defined travel preferences.
F-DS-04.04	The TDEI system shall utilize mobile applications to demonstrate the system providing data that supports spontaneous navigation of an end user's local environment.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.03	Have inputs (for origin, destination, trip-specific travel preferences) and instructions for path routing applications that are understood by the user.
POL-02	The TDEI system shall publish route information that is understood by the user to be "for information only," with no guarantee or expectation that the supporting data is accurate.
UN-DU10	Personalized travel planning and information services need to be available in multiple accessible formats based on the specific requirements of stakeholder populations with accessibility preferences in order to help them obtain information relating to transportation and improve their access to transportation services.
P-CO-08	The TDEI system's demonstration applications shall operate on standard Internet browsers or mobile devices (Android, iOS).

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P-CO-09	The TDEI system and all associated components shall send data successfully over landline or wireless Internet without priority or special accommodation (e.g., VPNs).
P-DU-05	The TDEI system and all affiliated tools shall be capable of operating in isolation from other components with reductions in features.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.01	Communicate route and navigation information to an end user in a manner that is interpreted by the application's targeted user group (e.g., using iOS or Android "accessibility" tags that are utilized by many population groups).
S-HF-06.02	Interface with an end user using communication methods that are understood by the user (e.g., haptic feedback, text-to-speech, etc.) for providing information, based on that application's target user group.
UN-DU11	Stakeholder populations with accessibility preferences need travel solutions that are responsive to their real-time needs and wants.
PER-01	The TDEI system shall be perceived as reliable by end users (e.g., with minimal system freezes, crashes, and failures).
SEC-06	The TDEI system shall introduce intermediary layers to secure communications with the interoperable data infrastructure and storage.
SEC-07	The TDEI system shall include an audit/reporting system that routinely scans for security risks.
SEC-08	The system design of the central database shall include redundancy and encrypted data archiving to ensure the continued operation of the system if major failures of or attacks on the system occur.
SEC-09	The TDEI system shall utilize NIST SP800-53, Recommended Security Controls for Federal Information Systems and Organizations for guidance to manage system safety risks.
S-HF-06	The TDEI system's demonstration applications shall:
S-HF-06.03	Have inputs (for origin, destination, trip-specific travel preferences) and instructions for path routing applications that are understood by the user.
S-MN-03	The TDEI system's demonstration applications should have a mechanism for user reporting of application errors.

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U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" 866-367-7487
www.its.dot.gov

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