Phase 1 Systems Engineering Management Plan (SEMP)

University of Washington ITS4US Deployment Project

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Final Report—February 7, 2022
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COMPLETE TRIP
ITS4US

U.S. Department of Transportation

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16. Abstract

This document discusses the Systems Engineering Management Plan (SEMP) 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.

The systems engineering methodology defines the SEMP as the top-level document that will guide the management of the systems engineering effort and act as the repository for project technical plans. The SEMP defines how the systems engineering portion of the project will be organized, structured and conducted and how the total engineering process will be controlled to provide a product that fulfills project objectives and requirements. The SEMP will be used by the UW ITS4US project team as a guide for the technical management of the TDEI system. Due to the iterative and adaptive nature of the software development proposed for the TDEI system, the format and content of this SEMP has been tailored to fit the Agile development process that will be applied to the TDEI system development.

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.

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Table of Contents

List of Tables

List of Figures

1. Introduction

1.1. Document Purpose

This document presents the Agile Systems Engineering Management Plan (SEMP), developed to guide the adaptive and iterative planning, design, procurement, and deployment processes of the University of Washington's (UW) ITS4US Deployment Project, referred to as the Transportation Data Equity Initiative (TDEI). 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. Without implementing this type of project, the needs of these communities will continue to remain unmet or underserved, limiting the ability of these citizens to access destinations, explore opportunities, and be aware of all services available to them.

When starting a complex project, managers must ask themselves how to deliver a quality product or solution and what processes or methods to employ to ensure a reliable, efficient use of stakeholder's time and funds. To address these questions, the UW ITS4US project team—in collaboration with the U.S. Department of Transportation (USDOT)—recommends using the systems engineering methodology for implementation of complex projects. The systems engineering methodology defines the SEMP as the top-level document that will guide the management of the systems engineering effort and act as the repository for project technical plans. The SEMP defines how the systems engineering portion of the project will be organized, structured, and conducted; and how the total engineering process will be controlled to provide a product that fulfills project objectives and requirements. The SEMP will be used by the UW ITS4US project team as a guide for the technical management of the TDEI system. Due to the iterative and adaptive nature of the software development proposed for the TDEI system, the format and content of this SEMP have been tailored to fit the Agile development process that will be applied to the TDEI system development.

A Systems Engineering Process is a structured way of thinking about and defining a complex system; it is an iterative approach to technical management, procurement, system design, product realization, and technical evaluation at each level of the system, beginning at the top and propagating those processes through a series of steps that eventually lead to a preferred system solution, and then continue through detailed design, deployment, integration, verification, and initial operations. The SEMP document is typically developed early in the process as a supplement to a Project Management Plan (PMP). While the PMP addresses general project management details—such as project scope, participating personnel, schedule of activities, task scheduling, and costs—the SEMP focuses on the technical plans and systems engineering processes that will be used to carry the project to its end.

Since the SEMP is developed early in the lifecycle of the project, it reflects only a partial understanding of what is to be deployed. Available information typically includes only the results

of the preliminary evaluations and needs assessments, as well as preliminary concept explorations that might have been conducted to assess project feasibility. As a result, several versions of the SEMP are typically released during the life of the project. For this version of the SEMP, several documents have been developed previously to help provide guidance:

- **PMP**—describes the activities throughout the first phase of the development effort.
- **User Needs Identification and Requirements Planning**—describes the plan for identifying and prioritizing user needs, and the process by which those needs will be handled within the project.
- **ConOps**—develops an informed vision and use cases for the products and systems to be refined through stakeholder and agency input.
- **Safety Management Plan**—describes potential hazards that users of the deployed system might encounter and how the project will keep those users as safe as possible.
- **Data Management Plan**—describes how data being collected of the project will be stored and shared, while maintaining the privacy of the individuals participating in the project.
- **Performance Measurement and Evaluation Support Plan**—describes key topics that need to be evaluated, as well as the sources of the data that are needed to perform those evaluations.
- **System Requirements**—establishes requirements that are traceable to user needs, vets those requirements with key stakeholders, and ultimately informs the verification testing effort that will be done once the system is built.

1.2. Project Overview

The project will develop a national pipeline to create, disseminate, and share standardized data about pedestrian environments, transportation environments, and on-demand transportation services to enable better use, discoverability, and data analytics of these assets and services. Specifically, the project will release nationally the OpenSidewalks data standard for digitizing pedestrian ways and will extend the national data standards for on-demand transit services (General Transit Feed Specification Flex or GTFS-Flex) and for mapping of multilevel transit stations (GTFS-Pathways). Additionally, the project will demonstrate the use of those data and standards in three applications: a multimodal, accessible travel planner (an extension of Access Map); an expansion of Microsoft's Soundscape application, which helps blind and low-vision people navigate and explore the environment; and a simulation tool to be built by Unity Technologies that allows travelers to explore the layout of transit stations prior to using those facilities.

This program recognizes that underserved individuals have differing and unique travel needs, even among individuals within a specific stereotyped user group. In addition, the ITS4US Program recognizes that there is often overlap between these populations, so opportunities exist to implement a solution that serves individuals in a customizable manner, rather than categorizing travelers into user groups. For example, slope steepness is not a concern of only users with certain disabilities (e.g., wheelchair users) or older adults, and it would be inappropriate to exclude such concerns from mobility applications that offer nonvisual directions simply because the stereotype for travelers with visual disabilities tends to overlook such concerns.

Figure 1. Infographic. Segments of a complete trip.

Source: United States Department of Transportation, University of Washington, and Cambridge Systematics.

User groups such as those described in **Table 1** represent demographic groups that experience greater travel barriers than some others. Importantly, these descriptions steer clear of typifying functional limitations or prioritizing specific travel concerns because it would be impossible to comprehensively describe the specific informational gaps experienced by these groups. Rather, the table describes specific life experiences that increase the likelihood of experiencing challenges during travel.

The goal of the UW ITS4US Deployment project is to build a sustainable, inclusive data infrastructure to enable and accelerate the future of equitable mobility and access to transportation for the benefit of all travelers. Through community leadership, this proposed system, the associated standards development, and the adoption by users (including both data generators and data consumers) will help provide a means to offer appropriate travel services, automate routing, and map out the transportation network in ways appropriate for every traveler. With this in place, previously underrepresented individuals will have tools available to make informed, customized travel decisions under any situation.

Table 1. Complete Trip—ITS4US deployment program user groups.

User Groups	Population Description
People with Disabilities	People with disabilities experience a broad range of travel limitations and associated needs. For the Complete Trip-ITS4US Deployment Program, four functional ability groups include individuals with mobility, vision, and cognitive/developmental and hearing challenges. Each of these groups experiences different transportation needs and barriers that may also vary significantly within the group. Some individuals have multiple disabilities.
Older Adults	Older adults form a substantial demographic of U.S. residents. There are approximately 50 million U.S. residents above the age of 65. As individuals age, many develop mobility, vision, hearing, and cognitive disabilities that make it difficult to travel on their own and necessitate reliable transportation services to maintain their independence and mobility. Approximately 35 percent of older adults have some type of disability, while two out of three have some form of chronic medical condition. Many older adults choose not to drive or are unable to drive. Accordingly, they are often in particular need of flexible, reliable, and affordable transportation to access medical appointments, shopping, or other necessary services.
Low-Income Populations	Low-income Americans, defined by the USDOT as persons whose household income is at or below the Department of Health and Human Services poverty guidelines, require reliable and affordable transportation. They are less likely to own private vehicles and therefore have increased need for access to public transportation.
Rural Residents	Rural areas are located outside urban regions and are characterized by very low-development densities. Dwelling units are widely dispersed (typically less than one dwelling unit per acre). According to the U.S. census, approximately 60 million Americans (one in five) live in rural areas, including high populations of older adults and veterans. Transportation options can be especially limited in low-density rural communities for individuals who do not own or cannot use a personal vehicle.
Veterans	Nearly 19 million veterans live in the U.S., and about one-quarter of the population has a service-related disability. Veterans with disabilities face unique challenges, as they usually have a sudden change in lifestyle and must adjust to their long-term disability as an adult. More than 40 percent of veterans live in areas considered rural.
LEP	People with limited English proficiency (LEP) are individuals whose primary language is not English and who have a limited ability to read, speak, write, or understand English. It includes people who reported to the U.S. Census that they speak English less than very well, not well, or not at all. According to the U.S. Census, nearly 26 million people were considered to have LEP in 2018, accounting for 8.5 percent of the population. Language for LEP persons can be a barrier for obtaining services and information relating to public transportation.

Source: United States Department of Transportation.

The UW ITS4US Deployment project aims to greatly increase the availability of pedestrian and transit pathway data and flexible transit information available to all travelers. It will build sustainable data infrastructure to enable and accelerate the future of equitable mobility and access to transportation. Specifically, it will implement and demonstrate data collection and data standards that allow a variety of mobility applications to access the information they need to support a wide range of mobility services for travelers of all abilities.

The project will achieve three primary goals:

1. **Coordinate Collaborative Releases of Data Standards**—Through community leadership, this project will cocreate, improve, and extend data formats that describe currently under- or unrepresented, detailed travel network information about the following:
   a. The pedestrian-built environment (sidewalks and footpaths) through the OpenSidewalks data standard.
   b. Transportation stations and hubs through the GTFS-Pathways data standard.
   c. Demand-responsive travel services through the GTFS-Flex data standard (excluding real-time feeds).

   In Phase 1, work in this topic area will include working with the various standards committees to ensure that changes made to those standards support the needs of travelers with disabilities and other mobility constraints, and specifically their need to identify paths and transit services that they can use. This includes the addition of new variables to the standards and the definitions for how those variables are coded.
2. **Publish and Maintain Interoperable Data Infrastructure**—During Phase 2, the UW Team will build, refine, and use data collection and data vetting techniques to generate data for all three data standards, along with the development of data provisioning services that distribute those data for use in a variety of applications. Much of the Concept of Operations (ConOps) will be devoted to the needs associated with these tasks. By the end of Phase 2, the UW Team will publish collected data for the six U.S. counties that are part of this project. Those data will be maintained for five years after the conclusion of Phase 3 of this project, thereby, supporting the team's and any third-party applications' interests in consuming the data. The six counties, as shown in **Figure 2**, are King and Snohomish Counties in Washington State, Multnomah and Columbia Counties in Oregon, and Harford and Baltimore Counties in Maryland.

Figure 2. Map. Washington, Oregon, and Maryland Counties.

Source: United States Department of Transportation, University of Washington, and Cambridge Systematics.

Data availability will depend on the cooperation of multiple agencies in those counties. This will be part of the outreach effort of the UW ITS4US project, but the results of that outreach effort are unknown at this time. GTFS-Pathways data will be demonstrated at transit centers in the three States. The exact number and locations of the transit centers will be a function of the comfort level of the transit agencies that will ultimately be responsible for maintaining the data and the overall cost of the data collection process.

3. **Deploy and Sustain Three Accessible Mobility Applications—**This project will deploy three accessible mobility applications in the evaluation and testing of the usability and efficacy of the data standards developed in Phase 1 and the supporting infrastructure developed in Phase 2. The mobility applications will close information gaps for three very different populations and will address demonstrably different travel goals:

    a. Multimodal AccessMap (by Taskar Center for Accessible Technology at the University of Washington (TCAT))—A comprehensive, multimodal, and 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.

    b. Soundscape (by Microsoft)—A specialized orientation and exploration mobility iOS application enabling blind, vision disabled, or deafblind travelers to perform spontaneous travel and explore new pedestrian environments without having to specify a destination.

    c. Digital Twin—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.

1.3. References

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

- Caspi, Anat and Hallenbeck, Mark. Phase 1 User Needs Identification and Requirements Planning (UNIRP), University of Washington ITS4US Deployment Project—April 12, 2021, Report Number FHWA-JPO-21-856.
- Caspi, Anat, et al., Phase 1 ConOps, University of Washington ITS4US Deployment Project, Final Report—June 28, 2021, Report Number FHWA-JPO-21-861.
- Caspi, Anat, et al., Phase 1 Data Management Plan (DMP), University of Washington ITS4US Deployment Project, Final Report—August 23, 2021, Report Number FHWA-JPO-21-869.
- Caspi, Anat, et al., Phase 1 Safety Management Plan (SMP), University of Washington 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), University of Washington ITS4US Deployment Project, Draft Report—September 8, 2021, Report Number FHWA-JPO-21-874.
- Caspi, Anat, et al., Phase 1 System Requirements Specification (SyRS), University of Washington ITS4US Deployment Project, Draft Report—October 25, 2021, Report Number FHWA-JPO-21-884.
- Federal Highway Administration (FHWA), Systems Engineering Guidebook for Intelligent Transportation Systems, Version 3.0, November 2009.
- Schwaber, Ken and Sutherland, Jeff. The Scrum Guide—November 2020. Available at: https://scrumguides.org/scrum-guide.html.

1.4. Organization of the Report

This document is organized as follows:

- **Section 1—Introduction.** This section will introduce the SEMP and define the purpose and scope of this document.
- **Section 2—Systems Engineering Process (SEP) Application.** This section defines, at a high level, the systems engineering processes that the UW ITS4US project will utilize for the remainder of the project lifecycle. This section also provides high-level overviews of the team structure and what the roles are within the project.
- **Section 3—Agile Process Application.** This section specifies, at a high level, the Agile processes the UW ITS4US project will use for those parts of the system that will use an Agile Development Process.

2. Systems Engineering Process Application

This section outlines the process planning and technical processes associated with the TDEI system. It aims to define the systems engineering processes that the UW ITS4US project will use for the remainder of the project lifecycle. It builds upon work started in the User Needs Identification and Requirements Planning (UNIRP) and details the processes used for the remainder of the systems engineering technical processes.

2.1. Systems Engineering Process

Traditional systems engineering processes for the intelligent transportation system (ITS) projects utilize the V-model approach, in which a project's development, deployment, and transition to operations are done through careful step-by-step documentation, prescribed sequential steps, and established project management. While this process is extremely useful for certain types of ITS deployments, the prescribed development activities can limit flexibility with systems that have a less straightforward design, particularly those that involve development of software. As an alternative approach, the Agile approach reframes the rollout of the project to be progress-oriented, demonstration-focused at various milestones, and receptive to ongoing feedback from stakeholders.

Each approach has its advantages and drawbacks. The USDOT has historically utilized the V-model approach for all Federally-funded ITS projects, but has utilized the Agile approach in some instances. Most recently, Agile was the systems engineering approach utilized for the Los Angeles County Metropolitan Transportation Authority's (LA Metro) Drayage, Freight, and Logistic Exchange (DrayFLEX) project.

A graphical illustration of the V-Model and Agile concept can be found in **Figure 3**, and further details on Agile will be discussed in subsequent sections. However, at a high level, the UW ITS4US project team anticipates that Agile is the best method for delivering tasks identified as part of Phase 2 and Phase 3 of the ITS4US project.

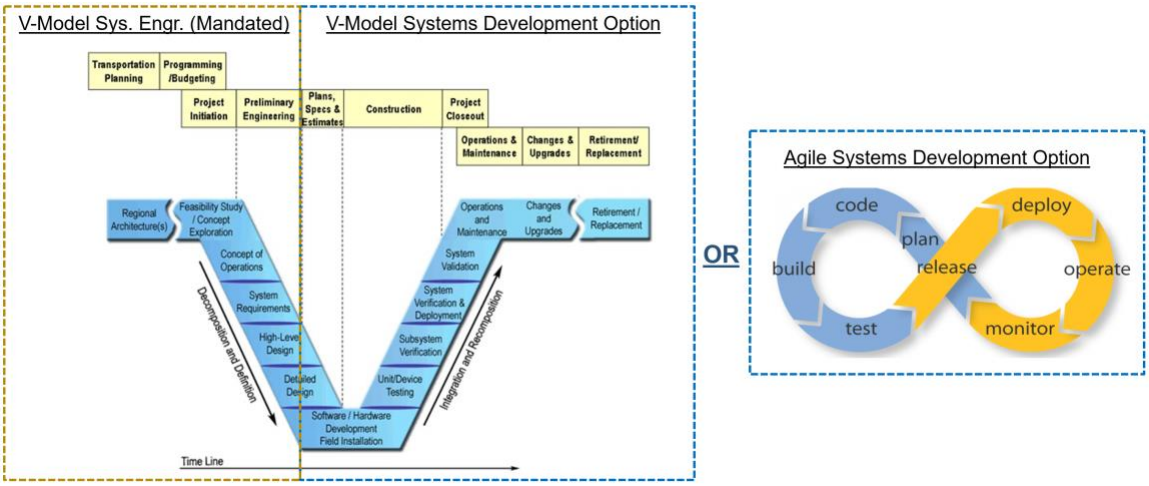

Figure 3. Diagram. V-Model and Agile Approach Concept.

Source: Federal Highway Administration, University of Washington, and Cambridge Systematics.

2.2. Systems Engineering Process Planning

This section discusses the high-level structure of the UW ITS4US project and processes that are applicable across the different systems engineering technical processes. It discusses the following items:

- Project Team Organization.
- Systems Engineering Deliverables.
- System Overview.
- System Constraints.
- System Milestones/Decision Gates.
- Standardized Processes.
- Defect/Discrepancy Processes.

2.2.1. Project Team Organization

The UW ITS4US project team is composed of highly skilled individuals to manage, develop, test, demonstrate, and conduct the necessary stakeholder outreach. Many of the roles and responsibilities of individual team members are still being defined, and likely will not be solidified until the kickoff of Phase 2, but the high-level vision for project team organization is discussed herein.

Table 2. Project Team Leads.

Name	Title/Position
Mark Hallenbeck, UW	Project Management Lead (PML)
Adam Danczyk, Cambridge Systematics	Systems Engineering Lead (SEL)
Anat Caspi, UW	Deployment Lead (DL)
Anat Caspi, UW	Verification and Validation Lead

Source: University of Washington and Cambridge Systematics.

The roles are defined as follows:

- The **Project Management Lead (PML)** will be responsible for the quality and timely provision of project management artifacts required in the contract and for tracking project progress against target performance throughout the project lifecycle. The PML is responsible for risk tracking and risk mitigation.
- The **Systems Engineering Lead (SEL)** will oversee the integration of technologies and services and manage planning integrated design, installation, operations, and maintenance. The SEL is responsible for the application of appropriate systems engineering (SE) processes and the quality of all SE artifacts. Most importantly, the SEL must manage the scope and detail of the SE process to ensure the quality of the artifacts developed, as well as ensuring that the SE process can be satisfactorily completed within the designated period of performance.
- The **Deployment Lead (DL)** will be responsible for articulating the vision, approach, and objectives of the overall deployment concept. The DL is responsible for creating team agreement on specific and practical performance measures, and for the implementation of performance management best practices. The DL is responsible for organizing and leading the deployment team partnership.
- The **Verification and Validation Lead** will be responsible for conducting system verification and validation. This will be a demonstration involving many parties led by the UW ITS4US project team. Since this happens after development and deployment has occurred, the roles will be filled by the same individual or their delegate.

2.2.2. Systems Engineering Deliverables

This section lists the major systems engineering deliverables in Phases 1, 2, and 3 of the UW ITS4US project. Proposed deliverables in Phase 2 and Phase 3 may adjust based on the scoping requirements established as part of Phase 2 and Phase 3 agreements. **Table 3** presents the anticipated systems engineering deliverables and a quick summary of what is included in these deliverables; several of these deliverables are highlighted again in Section 2.3 in the context of which technical processes would develop them.

Table 3. Systems Engineering Deliverables.

Deliverable	Phase	Summary
Phase 1 PMP	1	Defines how the project will be executed, monitored, and controlled. Draft and Final submission.
User Needs Identification and Requirements Planning	1	Details the processes for developing user needs and requirements. Draft and Final submission.
ConOps	1	Refines and improves the proposed complete trip deployment concept based on the systematic collection and analysis of user needs. Draft and Final submission, with stakeholder walkthrough event.
DMP	1	Describes the underlying data-related needs of the Deployment Concept. Draft and Final submission.
SMP	1	Describes the underlying needs associated with the safety of all individuals potentially impacted by the complete trip deployment. Draft and Final submission.
Performance Measurement and Evaluation Support Plan	1	Identifies performance measures, as well as plans for collecting data and reporting on performance. Draft and Final submission.
System Requirements Specification	1	Identifies the functional requirements, interface requirements, performance requirements, and data requirements of the deployment system. Draft and Final submission, with Walkthrough event.
Enabling Technology Readiness Assessment	1	Outlines all the technologies that may be part of the Deployment solution under development and the relative maturity of those technologies for deployment. Draft and Final submission.
Human Use Approval	1	Obtains Human Use Approval from an accredited Institutional Review Board (IRB).
Participant Training and Stakeholder Education Plan	1	A high-level plan for the recruitment and training of all travelers and other personnel participating in the Deployment. Draft and Final submission.
Institutional, Partnership, and Financial Plan	1	Codifies and provides definitive documentation of stakeholder agreement on concept, objectives, and institutional and financial arrangements. Draft and Final submission.

Deliverable	Phase	Summary
Outreach Plan	1	A high-level plan for the management of outreach activities in the deployment phases (Phase 2 and Phase 3). Draft and Final submission.
SEMP	1	Illustrates how the contractor will utilize the Systems Engineering process. Draft and Final submission.
Integrated Complete Trip Deployment Plan	1	Summarizes the refined Phase 1 deployment concept and sets forth a high-level Phase 2 and Phase 3 schedule. Draft and Final submission.
Deployment Readiness Summary Briefing	1	Demonstrates, from a programmatic perspective, readiness to initiate the Design/Build/Test Phase. Draft and Final submission.
Phase 2 PMP	2	Defines how the project will be executed, monitored, and controlled. Draft and Final submission.
Lessons Learned Logbook (LLL)	2	Logbook that captures lessons learned, including a succinct title, relevant agreement task, a summary of the issue identified, the realized/potential impacts, mitigating action(s) taken, and results identified (to date). To be updated monthly.
Systems Architecture Document (SAD)	2	Describes the architecture for systems associated with the deployment and associated standards that will be used. Draft and Final, including workbook development for walkthrough.
Systems Design Document (SDD)	2	Describes the full scope of the system. Subsystems of the system are identified and decomposed further into components. Requirements are allocated to the system components, and interfaces are specified in detail. Since the UW ITS4US project team will be using the Agile method, this will also define the product backlog, the sprint backlog, and the proposed release report. Draft and Final submission, including workbook development. Updates to ConOps, System Requirements, and Deployment Plan from Phase 1 may apply.
Data Privacy Plan (DPP)	2	Documents sufficient data privacy controls to mitigate the risk of harm to individuals that would result in the improper handing or disclosure of the Personally Identifiable Information (PII) and Sensitive PII (SPII) collected from individuals. Draft and Final submission.

Deliverable	Phase	Summary
DMP	2	Serves as an operational guide for managing data collectively as a strategic asset, and, subject to applicable privacy, security, and other safeguards, making data available to enable transparent system performance measurement; support independent evaluation; and fuel entrepreneurship, innovation, and economic development. Update from Phase 1, Draft and Final submission.
Comprehensive Acquisition Plan (CAP)	2	Identifies the type and number of devices, equipment, and software-based capabilities to be acquired. Draft and Final submission.
Comprehensive Installation Plan (CIP)	2	Identifies the types and number of equipment required to be configured and installed. Draft and Final submission.
Software Development Schedule (SDS)	2	Identifies the work breakdown structure (noting all dependencies among activities) required to make all development capabilities deployment ready. This will tie closely to the Proposed Release Schedule that will be defined as part of the SDD. Initial submission with recurrent updates.
Open-Source Software/ Source Code Management Plan	2	Identifies open-source software and supporting documentation to be provided in this task shall be identified as deliverables/milestones within the SDS. Publicly posting all identified open-source code and supporting documentation as specified by the Department of Transportation (DOT)-identified public software distribution platform is a deliverable under this task.
Training Implementation Schedule (TIS)	2	Creates a work breakdown structure of activities required to implement the Participant Training and Stakeholder Education Plan (PTSEP) in Phase 2. Initial submission with recurrent updates.
Training Materials	2	Documents prepared as specified in the PTSEP and TIS. Initial submission with recurrent updates.
Human Use Approval	2	Confirmation Materials, per the Human Use Approval Summary (HUAS).

Deliverable	Phase	Summary
System Test Plan (STP)	2	Documents the approach to verifying that the system meets its requirements and validates that it meets its user needs. Includes details on system verification and validation in the context of the release schedule. Draft and Final submission.
Operational Readiness Plan (ORP)	2	Documents elements for the operational tests and demonstrations. Draft and Final submission, with workbook for walkthrough.
Installation and Operational Readiness Testing Schedule (IORS)	2	A work breakdown structure of activities (and dependencies) required to implement the CIP and ORP. Initial submission with recurrent updates.
System Test Results Summary (STRS)	2	Provides the summary of test results from the testing outlined in the STP, which should include the pass/fail status of the tests conducted in each phase (Unit, Subsystem, Integration and System Acceptance); number of defects found; and number of defects resolved. The STRS shall also note any open defects, the severity/impact of those defects on the system, and the timeframe for when they will be resolved.
Comprehensive Maintenance and Operations Plan (CMOP)	2	Identifies the types and number of equipment required to be maintained. Draft and Final submittal.
Outreach Plan	2	Update of Outreach Plan from Phase 1. Draft and Final submittal.
Outreach Implementation Schedule (OIS)	2	A work breakdown structure of activities required to implement the Phase 2 Outreach Plan. Initial submission with updates.
Outreach Materials	2	As specified in Phase 2 Outreach Plan and OIS.
Performance Measurement and Evaluation Support Schedule (PMESS)	2	A work breakdown structure of activities (and dependencies) required to implement the PMESP (and DMP) for the specific purposes of the performance measurement and evaluation support. Initial submission with updates.
Revised HUAS	2	Updates to Phase 1 document as necessary per IRB approvals.

Deliverable	Phase	Summary
Standards Development Organization (SDO)-specific Technical Memoranda	2	To be defined in the Standards Plan within the SAD.
Program Management	3	Updates to PMP and LLL from Phase 2, along with other project management deliverables.
System Operations and Maintenance Schedule (SOMS)	3	Documents system installation and operational status. Initial submission with updates.
OIS	3	A work breakdown structure of activities required to implement the Phase 3 Outreach Plan. Initial submission with updates.
Operational Capability Showcase Plan (OCSP)	3	Highlights a plan to show the capabilities, intent, and value of the deployment as part of a media event. Draft and Final submittals.
Operational Capability Showcase Summary (OCSS)	3	Indicates how the results/products of the showcase have been integrated into site outreach materials and interactions in workshops, conferences, and trade shows. Draft and Final submittal.
Updates to Performance Measurement and Independent Evaluation	3	Updates made to the PMESS, the PMESP, DMP, site performance measurement dashboard, and other public-facing data.
Comprehensive Transition Plan (CTP)	3	Identifies the concepts, applications, governance framework, agreements, key documents, and equipment to be maintained as elements of routine operational practice after the completion of Phase 3. Draft and Final submittal.
SDO-Specific Technical Memoranda	3	To be defined in the Standards Plan within the SAD.
Monthly Progress Reporting	All	All other ongoing monthly deliverables and updates.

Source: U.S. Department of Transportation, Notice of Funding Opportunity Number 693JJ322NF00001, "Complete Trip—ITS4US Deployment Program Phases 2 and 3."

2.2.3. System Overview

The project will develop a national pipeline to create, disseminate, and share standardized data about pedestrian environments, transportation environments, and on-demand transportation services to enable better use, discoverability, and data analytics of these assets and services. The TDEI system aims to achieve USDOT ITS4US Program goals by deploying the following key technology elements:

1. **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 then accommodates data requests made through an Application Programming Interface (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.
2. **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.
3. **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:
    a. A comprehensive, multimodal, and 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.
    b. 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.
    c. 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.

Figure 4 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:

1. 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 4**, these components are labeled with a “1” and include the data processing pipelines, the data repository itself, and the service pipelines.
2. 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 4**, 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.
3. 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 4**, these components are labeled with a “3” and include Multimodal AccessMap from TCAT, the Digital Twin applications and Microsoft’s Soundscape.
4. 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 4**, 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.

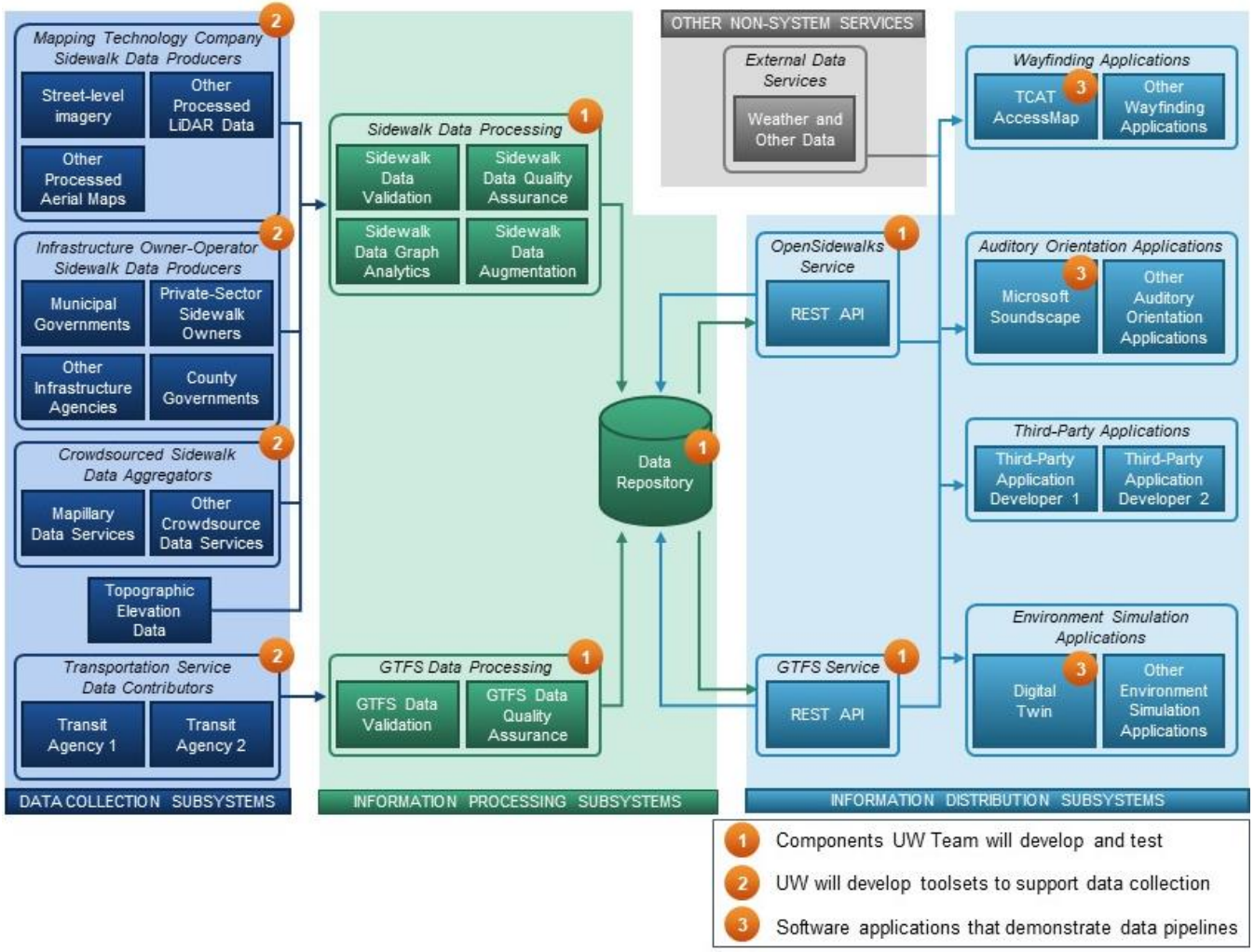

Figure 4. Diagram. Context diagram for the proposed Transportation Data Equity Initiative system.

Source: University of Washington and Cambridge Systematics.

2.2.4. System Constraints

The TDEI system has defined constraints that may impact the development and operation of the proposed system. These constraints were highlighted as part of the ConOps document and are noted below:

- **The stakeholder population is limited to certain groups as part of the design**. For purposes of this proposed system, the stakeholder population includes 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).

  Other stakeholders in applicable targeted user groups of the ITS4US Program—such as people with hearing challenges and veterans—may utilize and benefit from the proposed system, but the primary design focuses on the listed stakeholder groups.
- **Use of OpenSidewalks for sidewalk data—**The proposed system will utilize the OpenSidewalks data schema to map the pedestrian network, as it is a comprehensive format that aligns with the goals and objectives of the proposed system. It currently is in official draft standard form, meaning it may be subject to changes in the future. Such changes may require the proposed system to be modified if system objectives can only be solved with later schema, which may require iterative efforts.
- **Use of GTFS for transit service and station data—**The proposed system will utilize GTFS and its associated extensions as part of the transit feed data collection. GTFS is a widely adopted data standard among transit agencies, but—like all data schema—it has its limitations. Although this standard is the incumbent in the foreseeable future, other competing data schema may be adopted later. Such changes will require the proposed system to be modified to support future data schema, which will require effort by system operators.
- **Limitations of Data Schema for Proposed Data Standards**—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. While these data standards are likely to change with newer versions, each structured data schema will provide a constrained number of data input options.
- **Standards Adoption Timeline**—The proposed system intends to provide services to end users by utilizing standards that are still under development, namely the proposed GTFS extensions. Efforts concurrent to development of the proposed system aim to advance these standards into community agreement, acceptance, and adoption, but these steps are

dependent on other factors. Delays in adoption or emergence of competing alternatives can have impacts on the proposed system.

- **Reliance on AccessMap for Demonstration—**The proposed system intends to provide its services through the AccessMap platform, which will be modified to accommodate enhanced data feeds (new version will be referred to as Multimodal AccessMap). AccessMap is an existing platform that provides pedestrian-built environment information to users with specified preferences to help them make informed routing decisions. Like any existing software tool, it has some natural constraints due to its architecture, original design, existing policies, and current capabilities in terms of what it can deliver. It inherently relies on continued support from its sponsoring organization (TCAT). To mitigate reliance, the proposed system will allow for independent, third-party application developers to access the same data feeds and provide services as well.
- **Reliance on Soundscape for Demonstration—**The proposed system intends to provide its services through the Soundscape platform, which will be modified to accommodate enhanced data feeds. Soundscape is an existing platform that provides audible pedestrian cues to users with specified preferences to help them make informed routing decisions and explore the built environment that surrounds them as they travel. Like any existing software tool, it has some natural constraints due to its architecture, original design, existing policies, and current capabilities in terms of what it can deliver. It inherently relies on continued support from its sponsoring organization (Microsoft). To mitigate reliance, the proposed system will allow for independent, third-party application developers to access the same data feeds and provide services as well.
- **Reliance on Digital Twin for Demonstration—**The proposed system intends to provide its services through the Digital Twin platform, which will be developed to accommodate enhanced data feeds. Digital Twin is a proposed platform—to be built from other augmented reality tools that exist today—that will provide pre-trip, virtual reality simulation to allow travelers to explore their upcoming trip to help them make informed routing decisions. Like any existing software tool, it has some natural constraints due to its architecture, original design, existing policies, and current capabilities in terms of what it can deliver. It inherently relies on continued support from its sponsoring organization. To mitigate reliance, the proposed system will allow for independent, third-party application developers to access the same data feeds and provide services as well.
- **Geographical Limitations—**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. If a community was not collecting sidewalk information (either by the municipal government, private citizen crowdsourcing activities, or third-party data collection services), then the proposed system would consequently not be able to provide quality sidewalk routing data in that locale. Similarly, if transit service in that locale did not report service or station information, then the proposed system would not be able to provide that information either. Similarly, in environments where sidewalks and transit service did not exist, the proposed system could only report that such services were not available.

2.2.5. System Milestones/Decision Gates

The UW ITS4US project has many elements that make up its development, deployment, and operational schedule. The below bullets highlight some of the system milestones or decision gates that are envisioned in each of the respective ITS4US effort phases.

- **Phase 1**: This phase of the effort focuses on the planning-level concepts and systems engineering development. By the start of Phase 1, the UW ITS4US project team had already established several working groups of stakeholders that were helping inform the concept of the system, and the team was actively participating in the standards development work for OpenSidewalks and the GTFS extensions. Since no formal design development activities are occurring in Phase 1, critical milestones focus solely on completing this phase to make the system eligible for Phase 2/3 funding.
- **Phase 2**: This phase of the effort focuses on the design, development, and testing of the proposed system. By the start of Phase 2, the UW ITS4US project team would have received stakeholder feedback on the planning-level efforts to help further inform design, in addition to ongoing standards development and stakeholder workshops that the team is planning to undertake. Some potential milestones are highlighted as part of Phase 2:
    - Agreement on Standards and Appropriate Version—When system development occurs, the software will need to be coded to help transform data into the appropriate standard. The UW ITS4US is actively engaged in standards development groups, but most of these standards will likely continue to be developed into Phase 2; for example, new attributes may be identified that are relevant for trip making that were not included in previous versions of the standard. While the system ultimately is designed to be resilient to updates in data standards, the Development Team will need to identify a minimum viable standard from which to base the code development.
    - Involvement of a Commercialization Partner—One of the key interest areas for the TDEI system is the potential of this system to be commercialized in the long term by a data service provider that can deploy it to a wider audience. If a commercialization partner expresses interest, they may have additional criteria that will need to be incorporated as part of design and development. This milestone represents a decision point where designs may need to be adjusted to accommodate new user needs while still meeting the ITS4US project schedule. Any changes, if this option presents itself, would be reflected in the design schedule and coordinated with the USDOT.
    - Readiness of Demonstration Applications—One of the demonstration applications, Multimodal AccessMap, is being developed by the UW ITS4US project team and will utilize processes established by the project team and agreed to by the USDOT. Other demonstration applications are being developed independent of the ITS4US project; while there will be ongoing coordination as part of the design process, a significant milestone for the TDEI system is the completion of the demonstration applications prepared by other groups.
    - System Acceptance (Iterative and Complete)—Acceptance of technical components and validation by stakeholders is a key task that completes Phase 2. Although the proposed processes in this SEMP utilize an iterative method for verification and validation, the completion of all system acceptance tests (whether iterative or complete) is a critical milestone.

- **Phase 3**: This phase of the effort focuses on the operations and evaluation period of the proposed system. By the start of Phase 3, the UW ITS4US project team would have a viable TDEI system for demonstration of operations. Some potential milestones are highlighted as part of Phase 3:
    - Confirm Stakeholder Groups for Demonstrating System in Geographic Locales—Several geographic groups were identified in the UW ITS4US project team's Phase 1 proposal for demonstrating, including six counties in Washington, Oregon, and Maryland (two counties in each State). The UW ITS4US project team is coordinating regularly with these groups throughout Phase 1 and into Phase 2 but will need to confirm participation by the start of Phase 3 to kickoff the demonstration period.
    - Confirm Participants for Demonstrating System in Day-to-Day Use—Similar to other stakeholders, digital device end users will be necessary to show the success of the system. The UW ITS4US project team coordinates regularly with groups that would be part of this stakeholder group, but will need to confirm participation by the start of Phase 3.

2.2.6. Standardized Processes

The proposed content for the SEMP has been tailored from standardized outlines used by California Department of Transportation (Caltrans) and FHWA) and based on the Institute of Electrical & Electronics Engineers (IEEE) Standard 1220-2005, which is the International Council on Systems Engineering (INCOSE)-approved standard for developing an SEMP. For the UW ITS4US project, several processes will be ultimately followed. For the systems engineering work undertaken in Phase 1, which utilizes the traditional waterfall V-model approach, many of the processes comply with the format and guidelines of the International Organization for Standardization (ISO)/Institute of Electrical and Electronics Engineers (IEC)/IEEE 29148:2011 ConOps Standard (formerly IEEE Standard 1362-1998). For Phase 2, the UW ITS4US project team intends to transition to the Agile methodology, specifically utilizing the Scrum framework to help develop the TDEI system in design, deployment, and testing. The Scrum framework has several best practices that are defined in public documents. The most popular resource is a public document called *The Scrum Guide*, published and updated by Ken Schwaber and Jeff Sutherland who helped develop the concept. The latest edition is November 2020 and can be found online: https://scrumguides.org/scrum-guide.html.

2.2.7. Defect/Discrepancy Processes

Defects or discrepancies will be tracked as part of the monthly reporting to document identification, progress, and resolution (where possible). Details of how deficiencies or defects are handled and reported will be documented as part of the STP. Ultimate reporting will occur as part of the STRS, which will note the number of defects/deficiencies found and how they were resolved.

The UW ITS4US project team does not yet know which categories of defects/discrepancies will exist but acknowledges that many of the basic types of defects/discrepancies could apply. This includes:

1. **Arithmetic Defects:** Defects made by the developer in some arithmetic expression or mistake in finding solution of such arithmetic expression.

2. **Logical Defects:** Logical defects are mistakes done regarding the implementation of the code.
3. **Syntax Defects:** Mistakes in the writing style of the code.
4. **Multithreading Defects:** Running or executing the multiple tasks at the same time.
5. **Interface Defects:** Defects in the interaction of the software and the users.
6. **Performance Defects:** Defects when the system or the software application is unable to meet the desired and the expected results.

Many of these defects are detectable through user experience and evaluation against the system requirements. By using an Agile method for software development, the UW ITS4US project team hopes to identify any deficiencies/defects earlier in the process.

2.3. Systems Engineering Technical Processes

2.3.1. User Needs Processes

The UW ITS4US project team identified user needs from a variety of stakeholder groups. User needs were generated from previously published peer-reviewed research work; ongoing development and coordination workshops for data schema; creation of six stakeholder involvement groups for data standard review; ongoing co-design groups for proposed demonstration applications; and recruitment of agency, company, and community stakeholders. Additionally, the UW ITS4US project team has developed use cases through four previous years of research work and participatory design efforts.

Many of the details on previous, current, and future stakeholder engagement are highlighted in the UNIRP.

2.3.2. Requirements Processes

The UW ITS4US project team developed system requirements that could cover the collection, vetting, distribution/sharing, aggregation, and provision of routine access to data from external application developers. Each requirement was structured to meet several criteria (e.g., necessary, concise, solution-free, etc.) that fit the definition of a well-formed requirement. Requirements fell into three sets:

1. Those associated with collecting data.
2. Those associated with tasks required to transfer those data from the organizations that collect them to both the organizations that aggregate similar data from different sources, or that use them directly as one of many inputs to an application.
3. Those associated with the demonstration applications that utilize the data.

All system requirements were traced to the user needs defined earlier to confirm that the requirement was necessary and purposeful. Each requirement was decomposed into several requirement categories, with high-medium-low priority assigned based on whether the requirement was traceable to a user need that was deemed essential, desirable, or optional, respectively.

More details on system requirements planning and processes are highlighted in the SyRS.

2.3.3. Architecture and Interface Development Processes

As part of the Phase 2 effort, the UW ITS4US project team will develop a system architecture that reflects the comprehensive TDEI system, utilizing concept diagrams composed for the ConOps document in Phase 1. This system architecture is envisioned to be a conceptualization of the system requirements, informed by the specific requirements that were approved as part of the System Requirements document. This document will serve as the foundation from which subsystems can be separately developed using the Agile process, with their own respective milestones for confirming integration with the larger TDEI system.

The project team will develop the system architecture in Microsoft Visio or an equivalent software product, and the team will store this document electronically and update it whenever a high-level design change takes place. Any versions of this architecture submitted as part of a deliverable will be made available in Portable Document Format (PDF). Additionally, a change log will track architecture decision records when updates are made to the overall architecture.

This development process will produce (from **Table 3**):

- **SAD**—A brief document that reflects the high-level architecture and change logs. This document will include:
    - Interface Control Document—A brief document that provides high-level documentation of interface information between the TDEI system's defined subsystems.

These documents will be submitted in Phase 2 as part of the initial design processes. A draft and final version will be submitted. As these are living documents, the UW ITS4US project team will notify the USDOT when an update to these documents has been made in response to a design deviation often triggered later in the development process.

2.3.4. Design Processes

For the TDEI project, Phase 2 will utilize an Agile approach that develops the system incrementally as opposed to the traditional V-model approach that decomposes a high-level and detailed-design before development begins. Informed by various predecessor documents both in Phase 1 and Phase 2, the UW ITS4US project team will compose user stories and a development roadmap to serve as the design.

For this project, the UW ITS4US project team anticipates using the Scrum framework, which is one of the key types of the Agile Methodology. The Scrum framework utilizes a defined product backlog and levels of planning to orient a project team toward an overall project completion. The product backlog and delivery planning are discussed in greater detail in the following subsections.

Product Backlog

High-level design planning in Agile Software Development is centered around the Product Backlog, which is a prioritized list of product requirements called Backlog items or User Stories. For a larger project, it is usually not enough to have just one level of requirements in the Backlog. Instead, a hierarchy of Backlog items is introduced:

- **Theme:** Several Epics or stories grouped together by a common theme or semantic relationship. For a typical system, “User Management” can be a Theme. For the TDEI Project, themes will not likely be used.
- **Epic:** If a User Story does not fit within a Sprint (defined later in this section), it should be considered an Epic. The Epic will then be broken down into several User Stories, each of which can be fit into a Sprint. For the TDEI project, the team may utilize Epics that combine similar User Stories (discussed in the next bullet) that address several system requirements typically those that are affiliated with a similar user need.
- **User Story:** A User Story is a short description following pattern such as: “As a <Role>, I want <Action> so I can <Goal>” where <Role>, <Action>, <Goal> will change depending on the User Story. In addition, a User Story can have other attributes such as more detailed scenario descriptions. These scenarios are often described as “Given <Preconditions>, When <Action>, Then <Expected Result>”. This serves as a basis for testing of the User Story. For the TDEI project, User Stories will be informed by the system requirements document.
- **Task:** The levels described above are requirements descriptions. When a User Story is about to be implemented, it is broken down into several tasks. Tasks contain implementation details. For the TDEI project, tasks will be used by the Development Team.

It is worth noting that a Product Backlog is never complete. The earliest development of it only lays out the initially known and best-understood requirements. The Product Backlog evolves as the product and the environment in which it will be used evolves. The Product Backlog is dynamic; it constantly changes to identify what the product needs to be appropriate, competitive, and useful. If a product exists, its Product Backlog also exists.

Delivery Planning

The UW ITS4US project team will view the planning effort at various levels, utilizing the traditionally defined five levels of planning often used in an Agile product. These five include:

1. **Product Vision—**A clear description of why and for whom the product is made. This is typically a short separate document. No schedule information is provided here. *For the TDEI project, the Product Vision has been described in the ConOps document.*
2. **Product Roadmap—**The Product Roadmap is a coarse-grained schedule in terms of requirements and units of time. One- to six-month granularity can be used, but this depends on the project. Themes or Epics will be used here, but not individual User Stories. *For the TDEI project, this will be a plan detailing approximately 5 to 10 releases and containing the goals of each release. These releases could have goals such as integrating the data repository with the demonstration applications, or providing a tool for an agency to submit sidewalk data.*
3. **Release Plan—**The release plan shows in which Sprint a User Story is planned for. If the project is a year or more, only the next one to six months would be detailed in a Release Plan. Beyond that, a Product Roadmap would be used. *For the TDEI project, this means that the current and next release of approximately two to three months will be detailed to the Epic and User Story level at first. The releases beyond that will be specified only on the Product Roadmap level.*
4. **Sprint Plan—**A sprint represents a period of one month or less during which a “Done,” usable, and potentially releasable product Increment is created. The work to be

performed in the Sprint is planned as part of the Sprint Planning. During the Sprint Planning meeting, the Team commits to turning a set of Backlog items from the top of the Product Backlog into a working product increment.

5. **Daily Commitment—**What task a person is committed to doing today.

The different levels can be seen in **Figure 5**.

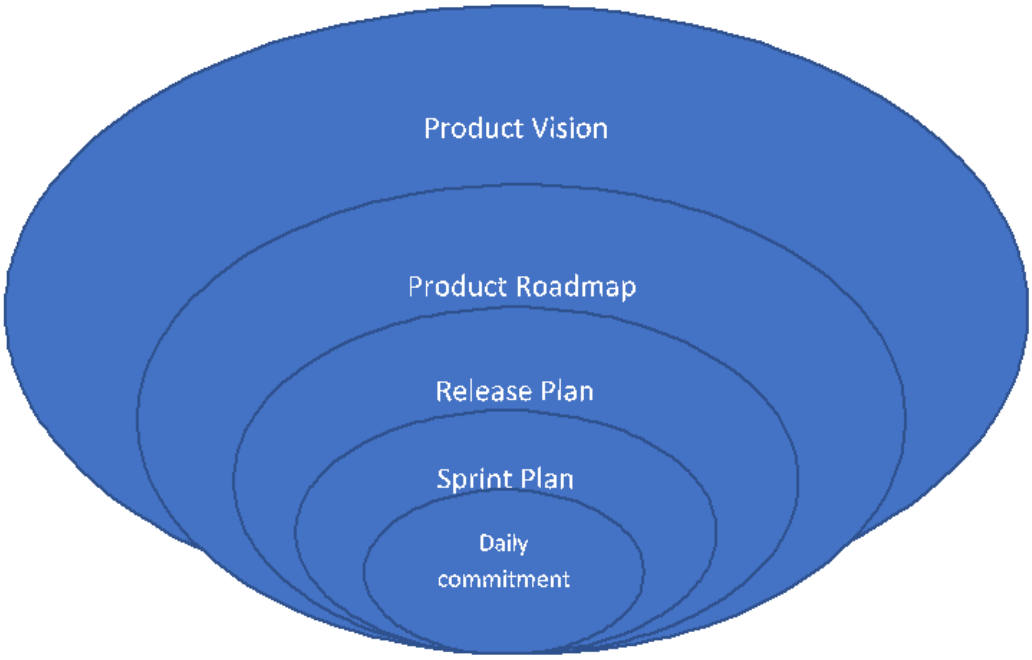

Figure 5. Diagram. Agile Planning "Onion": Five Layers of Planning.

Source: LA Metro, DrayFLEX Agile Systems Engineering Management Plan (A-SEMP), Final Report, April 2019.

During an Agile project, there will be updates to all levels of plans, but the updates will occur with different cadence. The Product Vision might be defined early in the project and never change. The Product Roadmap might only need a slight update every quarter. The Release Plan will likely be updated every few weeks or once a month. A Sprint Plan only lives during the Sprint. In Agile, it is acceptable to create detailed near-term activities, but keep long-term activities broader.

Deliverables

This design process will produce (from **Table 3**):

- **Systems Design Document:** This deliverable describes the full scope of the system. Subsystems of the system are identified and decomposed further into components. Requirements are allocated to the system components, and interfaces are specified in detail. This document will also touch on:
  - **Product Backlog Report:** A report that details an ordered list of everything that might be needed in the product—based on the User Needs and System Requirements that were

previously defined and accepted by the stakeholders. A common de factor standard is to describe backlog items as User Stories, which would be traced to system requirements.

  - Sprint Backlog and Proposed Release Report: A report that details the proposed releases and the breakdown of near-term sprints based on a set of product backlog items selected for that sprint. It will detail a high-level plan for delivering the product increment (a sum of all product backlog items completed during a sprint) and realizing the sprint goal.

- **DPP:** This document delivers sufficient data privacy controls to mitigate the risk of harm to individuals that would result in the improper handing or disclosure of the PII and SPII collected from individuals.
- **DMP:** This deliverable serves as an operational guide for managing data collectively as a strategic asset, and, subject to applicable privacy, security, and other safeguards, making data available to enable transparent system performance measurement; support independent evaluation; and fuel entrepreneurship, innovation, and economic development.
- **CAP:** This deliverable identifies the type and number of devices, equipment, and software-based capabilities to be acquired.
- **CIP:** This deliverable identifies the types and number of equipment required to be configured and installed.
- **SDS:** This deliverable identifies the work breakdown structure (noting all dependencies among activities) required to make all development capabilities deployment ready. This will align closely with the Proposed Release Report, defined earlier.

These documents will be submitted in Phase 2 as part of the initial design processes. A draft and final version will be submitted. As these are living documents, the UW ITS4US project team will notify the USDOT when an update to these documents has been made in response to a design deviation, often triggered later in the development process. These updates will likely occur as part of documentation submitted as part of development, discussed in the next section.

2.3.5. Development Processes

The UW ITS4US project team will develop the TDEI system starting with the proposed release schedule that was previously approved as part of the design (see earlier section). Prior to each release, the UW ITS4US project team will submit a draft and final planning memorandum that documents forecasted activities that will occur as part of that release, as well as the current relevance of those activities relative to other releases and the overall project. After each release, the UW ITS4US project team will submit a draft and final release report memorandum that discusses the outcomes of that release, progress made, and updates to the proposed release schedule (including greater detail on upcoming backlog work that has transitioned from long term to near term).

The Pre-Release Planning Memorandum aims to discuss the following topic areas:

- Key Features that are proposed for the release.
- A proposed release schedule, including a breakdown of sprints.
- Product backlog that will be addressed as part of the release, as well as traceability to the system requirements.

- Illustration of project architecture elements that will be addressed as part of the release, utilizing the proposed architecture that was submitted earlier (and any associated updates).
- Wireframes or mockups of features, as relevant to that sprint.
- Proposed stakeholder involvement that is relevant for that release and timeframes.
- A list of some or all other activities that are planned during this release in preparation for dependencies in future releases.

The Release Report Memorandum highlights outcomes from the release in the following topic areas:

- Key Features that were implemented in the release, and documentation of any deviations from those originally planned in the pre-release memorandum.
- Product backlog that was addressed as part of the release, as well as traceability to the system requirements. Any deviations from the product backlog originally planned in the pre-release memorandum will be noted here as well.
- Illustration of project architecture elements that were addressed as part of the release, utilizing the proposed architecture that was submitted earlier (and any associated updates). Any deviations from the project architecture originally planned in the pre-release memorandum will be noted here as well.
- Relevant excerpts from the project team's LLL, and/or log of Architecture Decision Record (ADR).
- Screenshots of features implemented in the release.
- Verification/Validation Testing that show features of the release allowing a system requirement to be met (note that a full verification/validation test will be necessary at the completion of the project).
- External stakeholder involvement that occurred as part of this release.

A pre-release memorandum and release report memorandum will be developed for each release of the overall project. While the length may vary depending on activities occurring in each release, a good expectation is 10 to 20 pages per memorandum with many pages showing illustrations or screenshots, keeping strictly with providing the necessary facts to stakeholders for documentation purposes and keeping the focus on development over documentation.

Figure 4 (earlier in this document) illustrates the context diagram of the proposed TDEI system, with three (3) separate key tasks for development across several components. For purposes of this SEMP, all systems and subsystems in the TDEI project will utilize the Agile approach, as the vast majority will be new software. This includes the Multimodal AccessMap demonstration application, which is existing software that will be augmented with new features and functionalities as part of this project; since it is owned by stakeholders on the UW ITS4US project team, it will follow the same Agile approach as the rest of the TDEI system.

An exception will occur with the Microsoft Soundscape demonstration application, which is an existing application that is being modified to work with data produced by the TDEI system. This application is privately owned by Microsoft and will very likely be developed in accordance with their own software development processes of which the UW ITS4US project team has little influence. That said, tasks affiliated with Microsoft Soundscape can be incorporated into the UW

ITS4US project team's proposed Agile approach by treating those tasks as serving a larger User Story, such as an Epic. This would allow all private development to occur with a defined milestone goal to signify its target for completion.

The UW ITS4US project team intends to make the TDEI system be an open-source development, in accordance with the broad agency announcement to allow this system to be shared broadly with the development community. Exceptions will include the Microsoft Soundscape demonstration application, which is an existing application used to demonstrate the TDEI system to digital device end users. During development of the TDEI system, all open-source code will be posted on a resource server that can be shared with the USDOT and its stakeholders at the end of each release. As of Phase 1, the UW ITS4US design team anticipates that GitHub may be a working repository for this open-source code, but this will be refined as part of Phase 2.

At the completion of the project, all open-source code will be submitted to the USDOT. The UW ITS4US project team will prepare a source code management plan prior to the start of the first Release that documents this proposed approach.

The releases and sprints are to be discussed in greater detail later in this SEMP. As part of development using the Scrum development methodology, the UW ITS4US project team will conduct a full cycle of tasks during each sprint development:

- **Backlog Grooming** is the maintenance process around an evolving Product Backlog list developed with the client that contains short descriptions of every piece of functionality for the system.
- **The Sprint Planning Meeting** is a time for the team to commit to product features they can implement for the next sprint. Before the Sprint planning meeting, the Product Owner ensures that the Product Backlog is in priority order, with the highest value features at the top of the list.
- **The Scrum Meeting** is a meeting of the entire team that lasts about 15 minutes and happens every morning and functions as a granular control point for the project to discuss Sprint progress.
- **The Sprint Review** is a time for the related stakeholders to meet at the end of a Sprint with the Development Team to review the working software that has been produced during that Sprint.
- **The Sprint Retrospective** is a meeting for the Development Team to review the development process of the previous Sprint and to engage in reflection with the goal of continuous improvement.

The team will host project status meetings, as needed, where key stakeholders are informed about the status of the project. More details about the different roles in this process are discussed later in the SEMP.

Deliverables

This development process will produce (from **Table 3**):

- **Open-Source Software/Source Code Management Plan:** This deliverable identifies open-source software and supporting documentation to be provided in this task shall be identified

as deliverables/milestones within the SDS. Publicly posting all identified open-source code and supporting documentation as specified by the DOT-identified public software distribution platform is a deliverable under this task. This updates and expands upon the information provided in Appendix B of this SEMP that discusses open-source software.

2.3.6. Implementation, Integration and Testing Processes

Most effort associated with implementation, integration, and testing will be captured as part of the releases discussed in the previous section. By establishing release goals and tracking dependencies, the TDEI system will be implemented and integrated by virtue of demonstrating successful user stories (tied to the system requirements). At the end of each release (and documented in the release report), acceptance testing will be done to demonstrate that the feature is performing as expected. This will need to occur for all releases.

The TDEI system will be deployed in three types of environments:

1. **Development/Integration environment**—Used to run Unit tests and Integration tests, often correlating to a release schedule.
2. **Testing/Staging environment**—A complete environment where complete system tests can be executed, and system verification can be performed.
3. **Production environment**—The production environment where users interact with the system to validate that original user needs are being met.

It is anticipated that, at the completion of a completed release, the TDEI system will operate in the production environment to maximize exposure to relevant stakeholders as the system develops. Releases will undergo system verification in the test environment. Sprints will undergo their tests in either the development or the testing environment, as appropriate. All these details will be documented in each Pre-Release Planning Memorandum, discussed in the earlier section.

As noted earlier, Microsoft Soundscape is an existing application that is being modified separate from the development of the TDEI system. This element will be treated as a task that serves a larger user story, allowing private development to occur with a defined milestone goal to signify how it can be considered tested and complete. This applies to verification and validation efforts as well, which are discussed in the next session.

Deliverables

This testing process will produce (from **Table 3)**:

- **STP:** This deliverable documents the approach to verifying that the system meets its requirements and validates that it meets its user needs. This will highlight the testing necessary for verification and validation in the context of each Agile release.
- **ORP:** This deliverable documents elements for the operational tests and demonstrations.
- **IORS**: This deliverable provides a work breakdown structure of activities (and dependencies) required to implement the CIP and ORP.

2.3.7. Verification and Validation Processes

Verification Processes

System verification represents the system acceptance testing portion of the project, which verifies that the system aligns with the system requirements that were outlined and affirmed by stakeholders as part of the System Requirements document. A successful demonstration that system acceptance is met will allow the system to graduate out of a test environment and into deployment.

The system verification process will produce a System Verification Plan document that will document the necessary steps for this system acceptance test. While this document is traceable to parts of the Phase 1 documents that were produced using the traditional V-model approach, much testing will be done as part of unit or integration tests done as part of each individual release, using the User Stories discussed earlier. The UW ITS4US project team will structure the System Verification Plan to focus on the User Stories that show traceability to the system requirements, calling back to previous test results where applicable. Initially, three categories of system requirement verification are anticipated:

1. **Untested or Retested User Stories:** For any user stories or system requirements not tested as part of a release, as well as any user stories or system requirements that were only tested as part of unit or integration testing during a release, the system will be demonstrated to successfully meet these stories/requirements as part of system acceptance testing. *The UW ITS4US project team anticipates that the vast majority of user stories will be tested as part of a release prior to system verification, and that anything untested at the end will be a very small quantity deemed necessary by the project team and the USDOT.*
2. **Previously Accepted User Stories:** Some user stories or system requirements may have been tested successfully as part of a release, and thus may already be considered accepted. In these cases, the user story or system requirement will not be retested as part of system acceptance testing. However, some user stories may necessitate a retest at the time of system verification. *The UW ITS4US project team anticipates that very few, if any, user stories would qualify for needing a retest due to previously being accepted (in a release) as meeting the requirement for a system test. However, if any are identified, they will be noted in the Draft System Verification Plan document for USDOT review and concurrence. For example, a User Story tested in the final scheduled release may overlap with a completed system.*
3. **Unincorporated System Requirements:** Some system requirements that were previously accepted as part of the Systems Requirement document may not be met by the current system due to design, policy, or other changes. While untraced system requirements will be noted as part of the Backlog Items/User Story development that USDOT will be able to review, this will be the formal declaration that the requirement ultimately was not met. Unincorporated system requirements will be documented here with justification given as to why they were not addressed. *The UW ITS4US project team will provide an opportunity for USDOT to review untraced system requirements as part of the Backlog Items planning (early in Phase 2), throughout the release schedule as things change, and as part of the System Verification Plan. This will be an ongoing discussion if any exist.*

System test cases are based on scenarios that are derived from the User Story being tested. The system test cases can be either manual test cases or automated test cases:

- **Manual test cases—**Test cases including test steps are described either in an issue tracking system or a separate document in a tool such as Microsoft Excel. These are executed, as needed, but not necessarily each time a User Story is integrated into the system.
- **Automated test cases—**Test cases are outlined in the issue tracking system. Detailed steps are described in test scripts that are stored in a source version control system. These are typically executed frequently to demonstrate recurrent success, like certain unit and integration tests. Another option is to execute the automatic system tests once per day instead of on every User Story integration.

All test cases will be available for review by USDOT and stakeholders by providing a formatted report from the issue tracking system or Microsoft Excel sheet holding the test cases.

Validation Processes

System validation represents the key stakeholder buy-in milestone for the project, where the proposed system is demonstrated to achieve the user needs that were defined as part of the UNIRP and ConOps documents. In a traditional V-model approach, system validation would focus on a period of performance starting after system verification to confirm with stakeholders that user needs and intended use align with what was set forth at the start of the project. In the Agile model, this will take on a slightly different approach, as system validation is an ongoing process during development and will continue throughout system operations to objectively confirm whether the application satisfies its intended use and users' needs.

In Agile, system validation is handled by two activities:

1. A Sprint Review is a recurring activity in which the implemented User Stories of the Product Increment are demonstrated to stakeholders.
2. The working product will be tested by smaller group of real users or members of a specific user group. This user testing can be performed for every increment or when a larger set of features is ready. This activity is also referred to as beta testing.

All feedback from these activities will be added to the Product Backlog and prioritized. The UW ITS4US project team will lead and document outcomes from this validation effort.

To demonstrate that all user needs have been reviewed, the UW ITS4US project team will develop a draft and final System Validation Plan. This plan will identify scenarios to support validation on how user needs are being met, touching on:

- **Objective—**Objective of the event, based on the wording of the needs.
- **Key user needs tested—**User needs to be validated in this event. For ease of tracing into the Validation Plan and other documents, the needs have a numerical reference from the ConOps.
- **Prerequisite tests—**Any other tests that must be satisfied before this event.
- **Key participants—**Participants required to coordinate, authorize, or conduct this event.
- **Support participants—**Participants that may be required for other support.

- **Information to be recorded—**Data or information to be recorded or noted during the event.
- **Pass criteria—**A statement of the pass/fail based on pass/fail criteria. This is simply a statement that the system satisfies the needs.
- **Assumptions and constraints—**Other important assumptions and constraints necessary for conduct of the event.

The system validation plan will also identify user needs that were not addressed as part of the TDEI system development, as well as provide a reason for this removal. This may not be known right away, as it often is contingent on knowing which system requirements are not being addressed before early indications exist that a particular user need may go unaddressed.

Deliverables

This process will produce (from **Table 3**):

- **STRS:** This deliverable provides the summary of test results from the testing outlined in the STP, which should include the pass/fail status of the tests conducted in each phase (Unit, Subsystem, Integration, and System Acceptance); number of defects found; and number of defects resolved. The STRS shall also note any open defects, the severity/impact of those defects on the system, and the timeframe for when they will be resolved. Specifically, it will address:
    - System Verification Results: A summary that documents the necessary user stories to be demonstrated by the proposed system to verify that the necessary system requirements have been met.
    - System Validation Results: A summary that documents the necessary testing scenarios that will be examined with stakeholders to validate that the necessary user needs in the ConOps have been addressed.

These documents will be submitted in Phase 2 in advance of the first release's completion.

2.3.8. Operations and Maintenance Processes

The operations and maintenance process begins when the first release of the TDEI system is deployed into the production environment, even though all system features may not be available yet. This means that operations and maintenance will commence in Phase 2, even though the demonstration and evaluation may occur more in Phase 3 and post-Phase 3. When the system enters production, it will be monitored for compliance with the necessary service levels, such as up-time performance and response times of system components. This also allows an opportunity to collect user-reported issues as stakeholders begin to interact with the system beyond the demonstrations that occurred as part of system verification and validation; likely through a problem ticket submission system.

Each new release will be added to the production environment in accordance with the project schedule. The UW ITS4US project team will aim to send new releases into production during the overnight hours when potential stakeholder use is low, even though this is not yet considered a full system. Once the full system is deployed, an established maintenance time will be published to help inform users of potential downtimes. It is unknown how frequent this patching schedule will occur.

Members of the UW ITS4US project team that are tasked with operating and maintaining the system will need some training to maintain critical operation features, troubleshoot minor issues, restore the system when necessary, and other tasks.

2.3.9. Post Phase 3 Processes

The UW ITS4US project team will sustain operations of the TDEI system for a period of at least five years after the completion of Phase 3. The UW ITS4US project team is exploring opportunities to extend the life of the TDEI system beyond that, particularly through discussions with commercialized data service providers who provide similar services to adopt the TDEI system as part of their offerings on a wide scale. None of this is known as of Phase 1, but ongoing outreach and discussion in forums and stakeholder meetings will hopefully identify opportunities to transition the system after the completion of the five-year operations and maintenance period.

The TDEI system is envisioned to continue receiving updates throughout the post-Phase 3 period. This includes both data contributions from data generators, transit service providers, and data service providers, as well as architectural updates issued through routine maintenance. It is anticipated that the UW ITS4US project team will manage updates that are issued as the need presents itself.

3. Agile Process Application

This section defines, at a high level, the Agile processes the UW ITS4US project team will utilize as part of Phase 2 design and develop efforts. The team envisions that Agile will be utilized for all design and development tasks that are directly within the team's purview, specifically the components that represent the data repository and the tools to help data generators create useful data. Updates to AccessMap also fall within the team's purview. Other third-party applications, specifically the Microsoft Soundscape demonstration application, are independent participants that will follow their own processes for development, but with a goal of achieving milestones that work collaboratively with the rest of the system.

Utilizing Agile allows the project team to establish key milestones, but also maintain some degree of flexibility to adjust delivery and solicit feedback from stakeholders. By completing sprints and releases that satisfy—discussed earlier in this document—the project team anticipates being able to deliver a product that more closely aligns with the project's user needs.

Figure 6. Diagram. Illustration of Agile sprints.

Source: University of Washington and Cambridge Systematics.

Figure 7 shows the context diagram for the proposed TDEI system, for reference.

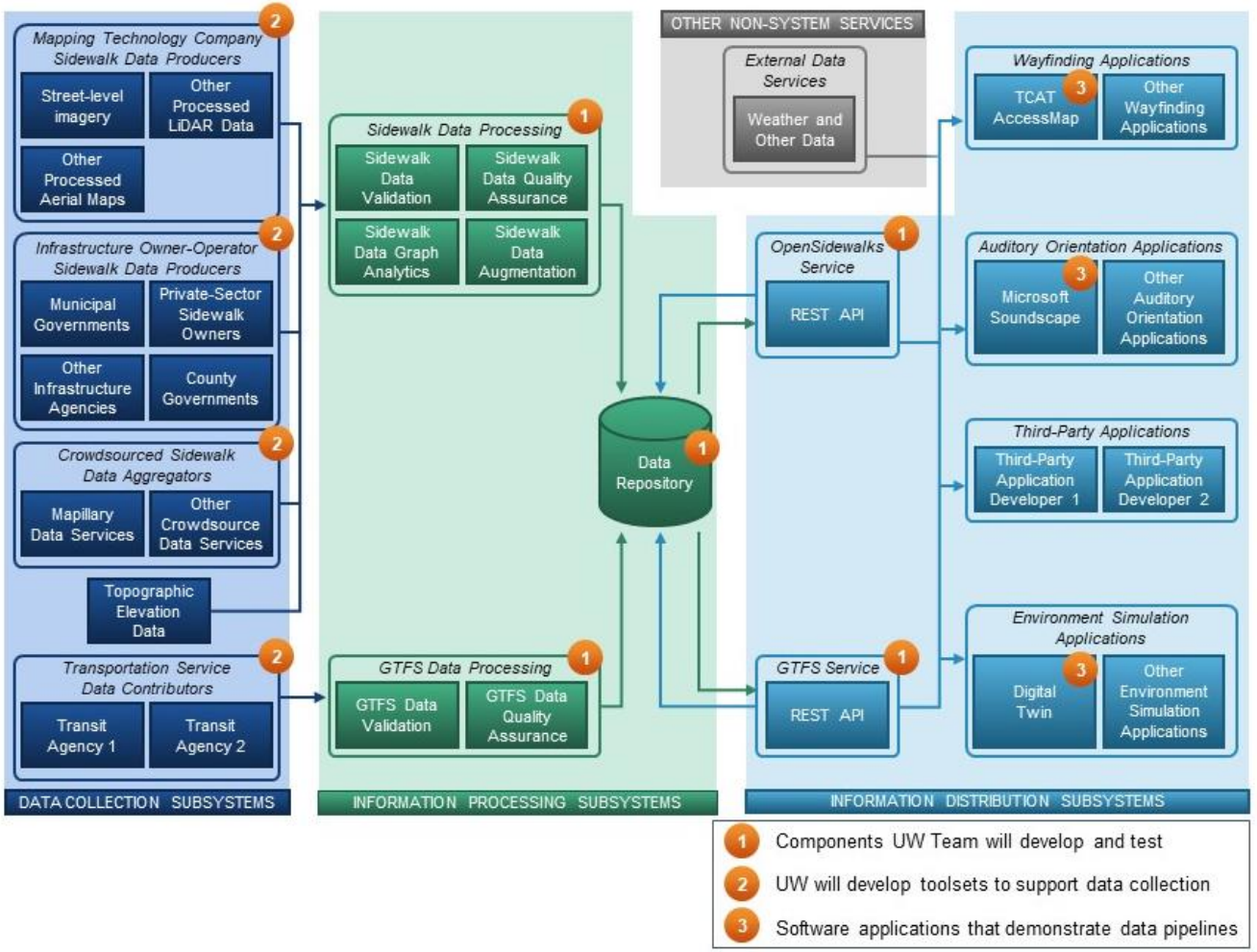

Figure 7. Diagram. Restated from earlier for clarity. Context diagram for the proposed Transportation Data Equity Initiative system.

Source: University of Washington and Cambridge Systematics.

3.1. Systems/Subsystems/Components Using Agile Development

This section highlights the parts of the system that will use the Agile development process. As noted earlier, the UW ITS4US project team anticipates use of the Scrum framework, which is one of the key types of the Agile Methodology as of Phase 1 of this project. The Scrum framework utilizes a defined product backlog and levels of planning to orient a project team toward an overall project completion. The subsystems highlighted below are envisioned to be releases in an overall Agile development process, with some of their subcomponents being part of the sprints. Each subcomponent may have various sprints, as they may touch on different stakeholder group types or data ingestion that requires multiple tasks.

The proposed components listed below are subject to change based on Phase 2 release planning, but are tentatively outlined here:

- Microservice Connectors Creation (in **Figure 7**, aligns with Callout #2 under the "data collection" subsystem for tasks defined as "UW will develop toolsets to support data collection").
- Data Interoperability Platform Development (in **Figure 7**, aligns with Callout #1 under the "information processing" subsystem for tasks defined as "Components UW Team will develop and test").
- API Development (in **Figure 7**, aligns with Callout #1 under the "information distribution" subsystem for tasks defined as "Components UW Team will develop and test").
- Demonstration Application Development (in **Figure 7**, aligns with Callout #3 under the "information distribution" subsystem for tasks defined as "Software applications that demonstrate data pipelines").

3.1.1. Microservice Connectors Creation

This task will focus on creating microservice connectors that facilitate data ingestion and integration to the TDEI's data repository to be developed under a separate release. It includes three key components:

1. Microservices to analyze queried API data and extract TDEI data-formatted metadata.
2. Microservices to transform data into TDEI data formats.
3. Artificial Intelligence Microservices to analyze batch data and extra TDEI data-formatted traveler information.

All microservices will ultimately load TDEI data into the data-sharing infrastructure.

Relevant user groups will include Data Generators, Transportation Service Providers, and Data Service Providers, as defined in the ConOps with their own respective user needs. It is anticipated that the quantity of sprints will be higher in this task, as there are many different stakeholder groups to coordinate with and several different components being built.

3.1.2. Data Interoperability Platform Development

This task will focus on creating the data interoperability platform that provides the TDEI system with data-sharing capacity. It includes two key components:

1. Aggregate of distributed data streams into the shared platform.
2. Batch processing.

This task focuses more on the internal system development than a direct application for user groups, but input from relevant user groups is still critical for ensuring that the data-sharing infrastructure can correctly accept data and produce data that is in the necessary format and structure. Relevant user groups may include the Data Generators, Transportation Service Providers, and Data Service Providers from the previous task, but may also include Application Developers as downstream services. It may also utilize the standards development to help inform viability of the data processing and storage from a data structure perspective.

3.1.3. Application Programming Interface Development

This task will focus on creating the APIs for data analytics and applications, which includes all interfaces necessary to enable downstream data use. Relevant user groups will include Application Developers and may include some of the Digital Device End Users depending on the particular need. This task will likely have a lesser quantity of sprints than other tasks due to being a more straightforward deliverable.

3.1.4. Demonstration Application Development

This task will focus on upgrading existing mobile applications to consume the data from the data repository. Relevant user groups will include both Application Developers and Digital Device End Users. It is very likely that completion of this task will occur near or at the end of the proposed releases, as it relies heavily on all other tasks to be complete to provide a functional result.

For Multimodal AccessMap, the full Agile framework will be utilized by the UW ITS4US project team. For other demonstration applications that are being developed independently with their own internal processes, the Agile framework will focus mostly on the completion of a release as a milestone delivery target for each respective developer to complete their internal product integration with the TDEI system.

It is likely that this task will occur as one of the later releases.

3.2. Systems Engineering-Agile Integration

The UW ITS4US project team has followed the traditional V-model systems engineering approach for Phase 1 of the ITS4US project. With the System Requirements document complete, the approach will transition to the Agile Scrum Framework prior to diving into the high-level design that would traditionally follow. Phase 2 tasks will continue using the Agile methodology until arriving at the system verification and deployment phases on the V-model approach, at which time will transition back to the traditional V-model diagram as the project transitions into Phase 3

Section 2.3.4 discusses the proposed Agile methodology for establishing product backlog and delivery planning. This will be done in coordination with the System Requirements document, as opposed to replacing it that some other projects may do.

Table 4. Systems Engineering—Agile Integration.

Systems Engineering Deliverable	Agile Deliverable
System Requirements	System Requirements document will serve as a supporting tool to inform Agile user stories. Document containing export from product backlog/issue management tool. Document includes the following sections: • Themes and Epics. • Detailed User Stories. Epics and User Stories as part of the Product Backlog. Some of the high-level requirements (Themes and Epics) can be documented at the requirement gathering stage; however, the detailed User Stories (lowest level requirements) are being developed gradually by Product Owner through the project development phase. These are stored in an issue tracking system.
High-Level Design	Two documents produced by exporting from design tools and logs: 1. Software Architecture document—Typically written in Microsoft Visio. This document is stored electronically and will be updated whenever a high-level design change takes place. A PDF report from the design tool will be delivered. 2. Lessons Learned Logbook—A log with short description of each architectural design decision made, why it was made, and the impact. This is an append only log that can be stored in source version control system or system such as Microsoft Teams. This document is also often referred to as an ADR.
Detailed Design	For each feature, the detailed design happens when the developer picks the story to work on, not as a separate phase before development.
System Development and Acceptance Testing	These deliverables will be stored in a version control system: • System Development source code with comments stored in version control system. • Unit tests are written as automated tests and are stored together with source code for the product in a source version control system. Executed and passing Unit tests as part of “Done” criteria for each Increment.

Systems Engineering Deliverable	Agile Deliverable
Verification Plan	These deliverables will be stored in a version control system: • Integration tests will be stored as source code (scripts) in a version control system. Executed and passing Integration tests as part of "Done" criteria for each Increment. The results of executed tests will not be reported in a separate document. • Manual system test cases: Test cases including test steps are described either in an issue tracking system or a separate document in a format such as Microsoft Excel. • Automated system test cases: Test cases are outlined in the issue tracking system. Detailed steps are described in test scripts that are stored in source version control system. Executed and passing System verification tests results are either tracked in issue tracking system or in Microsoft Excel.
Validation Plan	System validation is handled in two separate activities: 1. Sprint Review with stakeholders are held for each Increment. 2. The working product will be tested by a smaller group of real users (beta testing) or a specific user group. This user testing can be performed for every increment or when the larger set of features is ready. Some validation of the project for achieving goals can be done in the performance measurement plan.

Source: University of Washington and Cambridge Systematics.

3.3. Agile Team Roles

The UW ITS4US project team anticipates using the Scrum framework for this project's Agile methodology. Scrum utilizes a Scrum Team of one Product Owner, one Scrum Master, and developers. Within a given team, there are no subteams or hierarchies, but rather a cohesive unit of professionals focused on one objective at a time. In a proper Scrum Team, all roles are distinct from one another, they all are staffed by team members, and no hierarchy exists between people in one team. It is known that software development will be done by a combination of firms, including a number of specialty software development firms that work in the area of transportation navigation and streaming event data. The number of Scrum Teams that results from this—in terms of whether a single team or multiple teams are used—will be determined as part of Phase 2 Release Planning once further planning and coordination have occurred. It is anticipated that communication between teams will involve a UW ITS4US project team member leading the coordination of sprints, potentially utilizing a decoupled microservice architecture to enable different teams to work in parallel.

Scrum is not a standardized approach, but rather can have many minor variants so long as the underlying principles for the team are maintained. Other Scrum roles exist—namely the

stakeholders and user groups—that operate outside of the Scrum Team, but provide a valuable role.

Roles for the TDEI system development are defined in the following sections.

Product Owner

The Product Owner (PO) defines the product roadmap and maximizing the value of product. The PO needs a solid understanding of the business needs and industry so they can represent different user groups in the development process. Part of the PO responsibilities is to have a vision of what he or she wishes to build and convey that vision to the Scrum Team.

During the Agile development process, the PO has a critical role in guiding and interacting with the Scrum Team daily to respond to or clarify any questions about “What” needs to be developed. Failing to establish a PO role makes it difficult for the Development Team to know what is considered a maximized value.

The PO will be a member of the UW ITS4US project team.

Scrum Master

The Scrum Master (SM) is a separate leader who is responsible for promoting, supporting, and managing the Scrum process. This role works with the PO to establish release planning, facilitating the necessary events and meetings, and planning for implementations, as well as ensure that the goals, scope, and product are understood by the Development Team. This role is most often skipped, and often results in a loss of progress and control because the Development Team is too focused on the details to manage the process.

The PO will be a member of the UW ITS4US project team.

Development Team

The Development Team is a self-organizing team that is responsible for getting the actual work completed. This primarily includes software developers, but—depending on the scope—can include technical analysts, business analysts, solution architects, and Information Technology (IT) operations staff. The Development Team works comprehensively to develop and build out the solution; update the system of record (LLL or ADR) project status; provide documentation; support deliverable reviews; and test functionality for every increment and release. The Development Team works out the plan of action utilizing the project vision (provided by the PO) and controlled by the Scrum process (provided by the SM).

The Development Team will be composed of members of the UW ITS4US project team.

Stakeholders

Separate from the Scrum team are all other groups, which are considered stakeholders. Stakeholders on this project were defined in the ConOps document and include sponsoring organizations like the USDOT. Stakeholders provide perspectives and feedback on what the proposed system should do. Certain stakeholders—defined in User Groups, discussed shortly—will be directly involved in the Agile process by participating in sprint reviews. Other

stakeholders—such as “weather data providers” as defined in the ConOps—are anticipated to not be involved in Agile development directly, as their user needs are not directly tied to specifics that the TDEI system is developing. Needs of these groups will be factored into the initial release planning process, where it makes sense.

The USDOT’s role, as sponsoring organization, will be an exception, with participation and feedback offered through review of prerelease and releases memorandums. However, the more direct validation of user stories and system requirements is anticipated to be done by user groups.

User Group

A User Group is a group of stakeholders that plays a more direct role in the Agile process. These groups are used to inform and validate the user stories, provide feedback on completed functionality as presented in sprint reviews, and participate in pilot projects. Members of the user group will be informed at an early stage of the project, the type of input and feedback they are asked to provide, and how much time is required of the participants. Since the Agile process requires input from users at both the beginning of a project and throughout, the user group will also be informed early about the frequency of input that is required. The same users will participate in providing input and feedback throughout the project.

Members of the user group may include a representative from each stakeholder type defined in the ConOps that has a direct user need being addressed by the TDEI system; this will be determined once the release schedule is defined in Phase 2. It is anticipated that USDOT or its representatives will have the option to participate in this user group. Other members of the user group will receive the option to participate in all sessions, but the UW ITS4US project team intends to target their involvement to the specific releases that are relevant to their needs or interest areas to help balance their time and focus areas. This will be worked out in coordination with these members as the release schedule is established.

3.4. Communities of Practice

As part of the OpenSidewalks, GTFS-Flex, and GTFS-Pathways standards development, the UW ITS4US project team has access to a strong community of stakeholders that have an interest in this project at a technical level. Additionally, as part of coordination with disabled individuals and groups, the project team also has access to a strong community of stakeholders that will be the ultimate digital device end-user groups that will utilize the TDEI system for their daily use. Members from these groups will likely be identified to play a role in the Communities of Practice that will help inform the Agile processes. Although it is not fully known how many or which stakeholders will participate, they will likely come from one of the five existing Communities of Practice:

1. On-Demand Transit Service Providers.
2. Fixed-Route Transit Service Providers.
3. OpenSidewalks Groups—including cities/jurisdictions with sidewalks and/or sidewalk data.
4. Development Community—including those focused on developing products and services.

5. End User—Long-term users of the proposed systems. Also includes advocacy groups and other organizations that may participate in sidewalk data vetting.

The UW ITS4US project team will establish the process-focused Communities of Practice as part of the Phase 2 effort, likely once the release schedule is formulated into a draft-level document and the necessary reviewer types can be identified. It is anticipated that sprints will rely on smaller groups that are focused on the technical nature of the specific sprint. Releases, on the other hand, may rely on a broader group.

3.5. Agile Development Tools

The UW ITS4US project team intends to use an Agile development tool that provides some form of version control, reporting, testing, requirements management, and Agile-focused project management tools (including features for configuration management, road mapping, user story tracking, and communications). One common tool is Azure DevOps, although the UW ITS4US project team will not select the tool until more detail is known, likely closer to the kickoff of Phase 2.

3.6. Sprint and Release Planning

Release planning in Scrum occurs at the start of the effort and as part of every sprint, either as part of the sprint review or in the normal course of preparing for the subsequent event. Initial release planning involves collaboration between the stakeholders and the full Scrum team; and aims to accomplish a product vision, high-level product backlog, and a product roadmap. At this time, the releases may provide insight for stakeholder review on when the Minimum Viable Product (MVP) will be reached, although this may change once the project is initiated. The outputs from this effort will be documented in the Proposed Release Report found in the System Design Document.

Sprint and release planning will continue to occur as part of each sprint to determine the most valuable next release and the desired level of quality, noting various constraints regarding scope, deliverable date, and quality.

Product backlog items will not be formally chosen until sprint planning has occurred, although it is likely that the UW ITS4US project team will have a rough approximation of which features might be accommodated by near-term sprints. The Scrum team will create a sprint map using the product backlog and an estimated velocity of the Development Team (historic or estimated speed to complete tasks) to approximate which sprints can be fit in each release. The sprint map is anticipated to evolve throughout the development effort and will likely change right before the sprint begins. This is part of the Agile process and that helps maintain efficiency by being adaptable to lessons learned and environmental changes. Items along what is traditional viewed as the critical path will likely be developed in series (as these often require series-type completion of predecessor items before moving to the next item), but it is anticipated that other items could be developed in parallel utilizing multiple teams. As noted earlier, these multiple teams will be coordinated through a UW ITS4US project team lead, potentially utilizing a decoupled microservice architecture to enable different teams to work in parallel.

Length of sprints and releases will be determined in Phase 2, based on available information present at the time of design. In accordance with typical Agile processes, sprint planning typically

covers a horizon of two to four weeks out and is discussed in the context of “tasks” and “hours.” Release planning, on the other hand, is typically defined by “ideal days” or “story points.”

In sprint planning, the team should always talk of tasks and hours. Sprint planning covers the horizon of typically two to four weeks out. In release planning, the team can choose between "ideal days" and "story points." Release cycles are typically kept shorter than a year, often as short as three to six months. The exact details on timing will be determined as part of Phase 2.

Part of the sprint planning effort will include establishment of sprint retrospectives. Sprint retrospectives are formal reviews of past work to take an honest look at what went well and what did not go well. These retrospectives will be held by the team to help inform of how things can be done better in the future. Unlike a sprint review, which focuses on what happened during the project and is typically limited to managers and team leads, the retrospective emphasizes process and workload and includes the entire Scrum team to provide the perspectives of those entrenched in the work. Sprint retrospectives are anticipated to be held directly after a sprint review, prior to the start of a new sprint.

The MVP, for any subsystem or the TDEI system as a whole, will likely occur in one of the later releases, potentially the very last, due to the number of necessary development pieces that must be in place before a stakeholder can interact with the system. Details on this will be determined as part of Release Planning, but likely will occur when data (of any type) can be shared across interfaces of subsystems, both transmitted and received.

3.7. Agile User Demonstrations

Given that many stakeholders have limited time, the UW ITS4US project team proposes to conduct user demonstrations to stakeholders at strategic milestones. As noted earlier, sprint user demonstrations will occur among small groups. In many cases, this could be an update given as part of a routine coordination discussion with USDOT; stakeholders to participate could include project sponsors (USDOT) and the PO, as well as any other user group member deemed critical for inclusion with each sprint release. For release demonstrations, a larger user group will be utilized to demonstrate all the features produced by that release, show the test results or conduct the necessary testing procedures, and solicit feedback.

As noted earlier, each release will be considered a deployment, with each subsequent release building upon the previous one. New releases are only deployed after a user demonstration occurs and all feedback from stakeholders has been addressed (or noted for deferment into a later release, with stakeholder concurrence).

Appendix A. Acronyms and Glossary

Acronym	Definition
ADR	Architecture Decision Record
API	Application Programming Interface
Caltrans	California Department of Transportation
CAP	Comprehensive Acquisition Plan
CIP	Comprehensive Installation Plan
CMOP	Comprehensive Maintenance and Operations Plan
ConOps	Concept of Operations
CTP	Comprehensive Transition Plan
DL	Deployment Lead
DMP	Data Management Plan
DPP	Data Privacy Plan
DOT	Department of Transportation
DrayFLEX	Drayage, Freight, and Logistics Exchange
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
HUAS	Human Use Approval Summary
IEC	Institute of Electrical and Electronics Engineers
IEEE	Institute of Electrical & Electronics Engineers
INCOSE	International Council on Systems Engineering
iOS	iPhone Operating System
IORS	Installation and Operational Readiness Testing Schedule
IRB	Institutional Review Board
ISO	International Organization for Standardization
IT	Information Technology
ITS	Intelligent transportation system
ITS JPO	Intelligent Transportation Systems Joint Programs Office
LA Metro	Los Angeles County Metropolitan Transportation Authority
LEP	Limited English Proficiency
LLL	Lessons Learned Logbook
MVP	Minimum Viable Product
OCSP	Operational Capability Showcase Plan
OCSS	Operational Capability Showcase Summary
OIS	Outreach Implementation Schedule
ORP	Operational Readiness Plan
PDF	Portable Document Format
PII	Personally Identifiable Information

Acronym	Definition
PMESS	Performance Measurement and Evaluation Support Schedule
PML	Project Management Lead
PMP	Project Management Plan
PMESP	Performance Measurement and Evaluation Support Plan
PO	Product Owner
PTSEP	Participant Training and Stakeholder Education Plan
SAD	Systems Architecture Document
SDD	Systems Design Document
SDO	Standards Development Organization
SDS	Software Development Schedule
SE	Systems engineering
SEMP	Systems Engineering Management Plan
SEL	Systems Engineering Lead
SEP	Systems Engineering Process
SM	Scrum Master
SMP	Safety Management Plan
SOMS	System Operations and Maintenance Schedule
SPII	Sensitive Personally Identifiable Information
STRS	System Test Results Summary
STP	System Test Plan
SyRS	System Requirements Specification
Taskar Center or TCAT	Taskar Center for Accessible Technology at the University of Washington
TDEI	Transportation Data Equity Initiative
TIS	Training Implementation Schedule
UNIRP	User Needs Identification and Requirements Planning
U.S.	United States
USDOT	United States Department of Transportation
UW	University of Washington

Appendix B. Source Code Management Plan

The source code management plan is a high-level plan that outlines how source code will be managed during Phase 2 of the ITS4US project. Source code management is used to track modifies to a source code repository, allowing an ongoing tracking of changes to the code base to help resolve conflicts between multiple contributors. It is often referred to as Version Control, Revision Control, or Source Control.

As part of the kickoff to Phase 2, the UW ITS4US project team will establish processes to manage source code, utilizing the best tools that are available at the time of development. Some best practices that will be considered include, but are not limited to, the following:

- **Commit Often:** Make frequent and routine commits to capture updates to the codebase, allowing for opportunities to revert or undo mistakes.
- **Employ Processes to Receive the Latest Version:** Utilize tools to ensure use of the latest code before making updates.
- **Make Detailed Notes:** Require developers to explain the "why" and "what" in each commit log notes.
- **Review Changes Before Committing:** Utilize tools to stage a group of edits before writing them to a commit.
- **Use Branches:** Utilize branching tools to allow developers to create separate lines of development, allowing them to work in parallel. Completed development can then merge a branch into the main line of development.
- **Agree on Workflow:** Establish patterns and processes for merging branches that are agreeable to the development team to help improve efficiency.

Open-Source Software

Figure 4 in the main document shows a context diagram for the proposed TDEI system, with callouts illustrating the various development efforts occurring as part of this system. It is anticipated that the data repository will be open-source software, open to the community for other open-source software developments. It is anticipated that this open-source software would be stored as part of GitHub, which is one of the community-facing tools utilized for standards development as a component of this effort. These items are denoted with Callout #1 in **Figure 4**.

For the tools that will be developed to aid public agencies with generating sidewalk data, it is anticipated that these tools will be open-source software, open to the community for other open-source software developments. Like the above, this open-source software would be stored as part of GitHub. These items are denoted with Callout #2 in **Figure 4**.

Multimodal AccessMap will serve as one of the demonstration applications, denoted as Callout #3. Since this will be developed by the UW ITS4US project team, this software will be Open Source, stored as part of GitHub.

Existing Software Development Processes and Policies

Figure 4 shows the demonstration applications, denoted as Callout #3, that will be used by this project to show the success of the TDEI system in terms of digital device end users being able to utilize the data resources. These demonstration applications are existing applications that are being updated as efforts outside of the USDOT-funded initiative. Some of these demonstration applications, specifically Soundscape, are developed by Microsoft, which utilizes proprietary development processes and source code management structures that are not available to the public. This source code is not considered open source and, thus, will not be posted on a public-facing forum, but rather managed internal to each organization based on their organization policies regarding source code management.

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