Phase 1 Systems Engineering Management Plan (SEMP)

CALACT ITS4US Deployment Project

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Final Report — March 1, 2022
FHWA-JPO-21-916

COMPLETE TRIP
ITS4US

U.S. Department of Transportation

Produced by California Association of Coordinated Transportation ITS4US Deployment Program, Phase 1
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Robert Sheehan, COR

16. Abstract

The Systems Engineering Management Plan provides an overview the management approach that will be used to design, develop, and deploy the Proposed System during Phase 2 and 3 of the CALACT ITS4US Deployment Project This includes descriptions of the proposed team and organizational structure, titles and responsibilities of team members, and software development and validation processes. The systems engineering process will be used to deploy the proposed within four designated deployment sites. The proposed system entails a series of components which include governance bodies, published resources, software applications, and labor services provided by or coordinated by the project team. Software components will follow an Agile methodology for the ongoing design and development of new features.

Section 1 provides an introduction and overview of the project as a whole. Section 2 covers the Systems Engineering Process including planning and technical processes. Section 3 details the Agile process that will be used including team members and roles, sprint and release planning schedules, and development tools.

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1 Introduction

This document is the Systems Engineering Management Plan for the CALACT ITS4US project. The introduction section will provide an overview of the project and purpose of this document.

1.1 Document Purpose

The purpose of this document is to overview the management approach that will be used to design, develop, and deploy the Proposed System according to the System Requirements detailed in the CALACT ITS4US Phase 1 System Requirements Specification (SyRS). This document will describe the proposed team organization and processes which will be responsible for each aspect of system development, including responsibilities of team members, relationships and communications between team members, validation processes, software development processes, and system maintenance processes. This document covers work happening during Phase 2 and 3 of the ITS4US project.

1.2 Project Overview

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

The demand-response systems themselves offer a lower quality of rider experience, where would-be passengers must find a transit provider that will serve their needs, call a dispatch system to plan and reserve their trip, requiring a long lead time (typically at least a day in advance), and allowing little room for flexibility. The trip planning experience of demand-response systems is further and uniquely burdened by a complex web of determining operator coverage area, for what qualifications that operator or specific service within that operator's service menu they qualify, if the operator has availability, if they need to pay and how. Unlike fixed route services, which have a well-established data standard and a stable industry of third-party trip planning services, and private Transportation Network Companies (TNCs), which produce their own seamless and instantaneous booking and payments flows, demand-responsive transit lacks the technical solutions which could ease these burdens for their riders. There's no comparable

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

desktop or smartphone experience and no other innovations which exist to untangle these webs of availability, reservations, or payments.

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

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

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

Project partner (subcontractor) organizations include:

- Oregon Department of Transportation (ODOT): Agency outreach in Oregon, member of PMT, transit directory product manager
- Washington Department of Transportation (WSDOT): Agency outreach in Washington, member of PMT, transit analysis product manager
- California Department of Transportation (Caltrans): Agency outreach in California, member of PMT, payments product manager
- Washington State Transit Association (WSTA): Support agency outreach in WA and assist with event coordination
- Trillium, an Oregon small business: Concept design, report writing and product management support
- Compiler LA, a California small business: Software systems requirements and data management lead
- Tamika L. Butler Consulting, a California small business: Internal evaluation and stakeholder engagement

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

1.3 Acronyms and Glossary

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

ADA - Americans with Disabilities Act

API - Application Programming Interface

CA - State of California

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

CALACT - California Association for Coordinated Transportation

Caltrans - California Department of Transportation

CDL - Concept Development Lead

CMMI – Capability Maturity Model Integration

ConOps - Concept of Operations

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

DOT - Department of Transportation

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

GPS – Global Positioning System

GTFS - General Transit Feed Specification

IEC – International Electrotechnical Commission

IEEE - Institute of Electrical and Electronics Engineers

INCOSE - International Council on Systems Engineering

ISO – International Organization for Standardization

PII – Personally Identifiable Information

PLC - Project Leadership Committee

PML - Project Management Lead

PMO - Project Management Organization

PMP - Project Management Plan

PMT - Project Management Team

ODOT - Oregon Department of Transportation

OR - State of Oregon

OS - Operating System

SCC - System Coordination Committee

SDL - System Development Lead

SEMP - Systems Engineering Management Plan

SyRS - System Requirements Specification Document

TBD - To Be Determined

TNC - Transportation Network Company

UI - User Interface

WA - State of Washington

WBS - Work Breakdown Structure

WSDOT - Washington State Department of Transportation

WSTA - Washington State Transportation Association

1.4 References

CALACT Phase 1 Concept of Operations (ConOps), USDOT (2021).

CALACT Phase 1 Outreach Plan, USDOT (2021).

CALACT Phase 1 Performance Measurement and Evaluation Support Plan (PMESP), USDOT (2021).

CALACT Phase 1 Safety Management Plan, USDOT (2021)

CALACT Phase 1 System Requirements Specification (SyRS), USDOT (2021).

CALACT User Needs Identification and Requirements Planning report, USDOT (2021)

2 Systems Engineering Process (SEP) Application

This section describes the management approach that will be deployed to successfully deploy the proposed system. Section 2.1 describes the system, the planned team organization, and the key documents and decision points which will guide system deployment. Section 2.2 walks through the major phases of the deployment process, from architecture to validation to ongoing maintenance during and after the project timeframe, and describes the approach to be followed by the project team.

2.1 Systems Engineering Process Planning

A systems engineering process will be used to deploy the proposed system (See Figure 1. Proposed System Diagram) within four designated deployment sites. The proposed system entails a series of components which include governance bodies, published resources, software applications, and labor services provided by or coordinated by the project team. Each of these components will be designed, developed, deployed, operated, and maintained on timeframes appropriate to the particular component. All system components will also continue to be redesigned, redeveloped, and redeployed during operations and maintenance. Software components will follow an Agile methodology for the ongoing design and development of new features. Other system components will also be reconsidered and released periodically, but will not strictly follow Agile methodologies. This section lays out the team and key procedural resources which will be developed and used during the project.

2.1.1 Project Team Organization

The project team is organized under three managers who are responsible for designing, developing, and implementing the proposed system. These managers are responsible for the system delivery according to the system requirements identified in the SyRS. Any change in the system requirements defined in that plan must be considered by the System Coordination Committee (SCC).

- Project Manager – The Project Manager is the Project Management Lead (PML) for the project. This individual
    - reports to the SCC and USDOT COR on the progress of system deployment and performance
    - oversees the work of the Data and Software Manager
    - oversees the work of the Deployments Manager

  - is responsible for the delivery of all project reports and Systems Engineering deliverables

  - owns the Technology Coordination Teams system component, including leading the creation of architecture and design documentation for that system component, managing all staff contributing to the development of that component, and managing all staff contributing to the operations of that component except within deployment sites 2 through 4.

- Data and Software Manager – The Data and Software Manager is the System Engineering Lead (SEL) for the project. This individual

  - reports to the Project Manager

  - oversees the work of the Data Junior Staff, Senior Developer, and Contract Developers

  - owns all system components other than the Technology Coordination Teams and SCC, including leading the creation of architecture and design documentation for these components and managing all staff contributing to the development of these components

  - collaborates with Deployments Manager to ensure fitness of system components to deployment site needs, supports deployment of system components, and manages new design and development work that arises during system operations

- Deployments Manager – The Deployments Manager is the Deployment Lead (DL) for the project. This individual

  - reports to the Project Manager

  - performs all project management communications related to the local deployment sites and coordinates resources to support successful local deployment sites

  - collaborates with the Data and Software Manager to ensure fitness of system components to deployment site needs and project manages the deployment process for all system components except the Technology Coordination Teams

  - collaborates with internal evaluation team to support successful performance measurement data collection

  - manages ongoing work directly associated with deployment site activities necessary for the operation of software components of the project, and requests maintenance or enhancement of the software components from the Data and Software Manager

  - manages the operations of the Technology Coordination Teams within Deployment Sites 2 through 4, and manages the operations of the 1st Tier

Support Desk in Deployment Site 3 including any allocation of labor from the project contributing to those operations

The three managers will be in charge of all project activities, and each is allocated to the project at least 24 hours per week. They will meet with each other at least weekly, to ensure consistent coordination between different aspects of the project.

Other team functionalities include

- System Coordination Committee – this is the governance body of the project, and is responsible for overseeing the work of the Project Manager and considering any change to the system requirements. It is also responsible for the development of a long-term governance framework for the project after Phase 3.

- Training Assistance Contractors – these contractors report to the Project Manager, and provide services related to training users of the system.

- Technical Advice Contractors – these contractors report to the Project Manager, and provide technical advice related to their subject matter expertise, for use by the project.

- Data Junior Staff – these contractors report to the Data and Software Manager, and provide data development and data quality review services.

- Senior Developer – this contractor reports to the Data and Software Manager, and provides development services across all software components of the project.

- Contract Developers – these contractors report to the Data and Software Manager, and provide development services specifically for scopes related to individual software components.

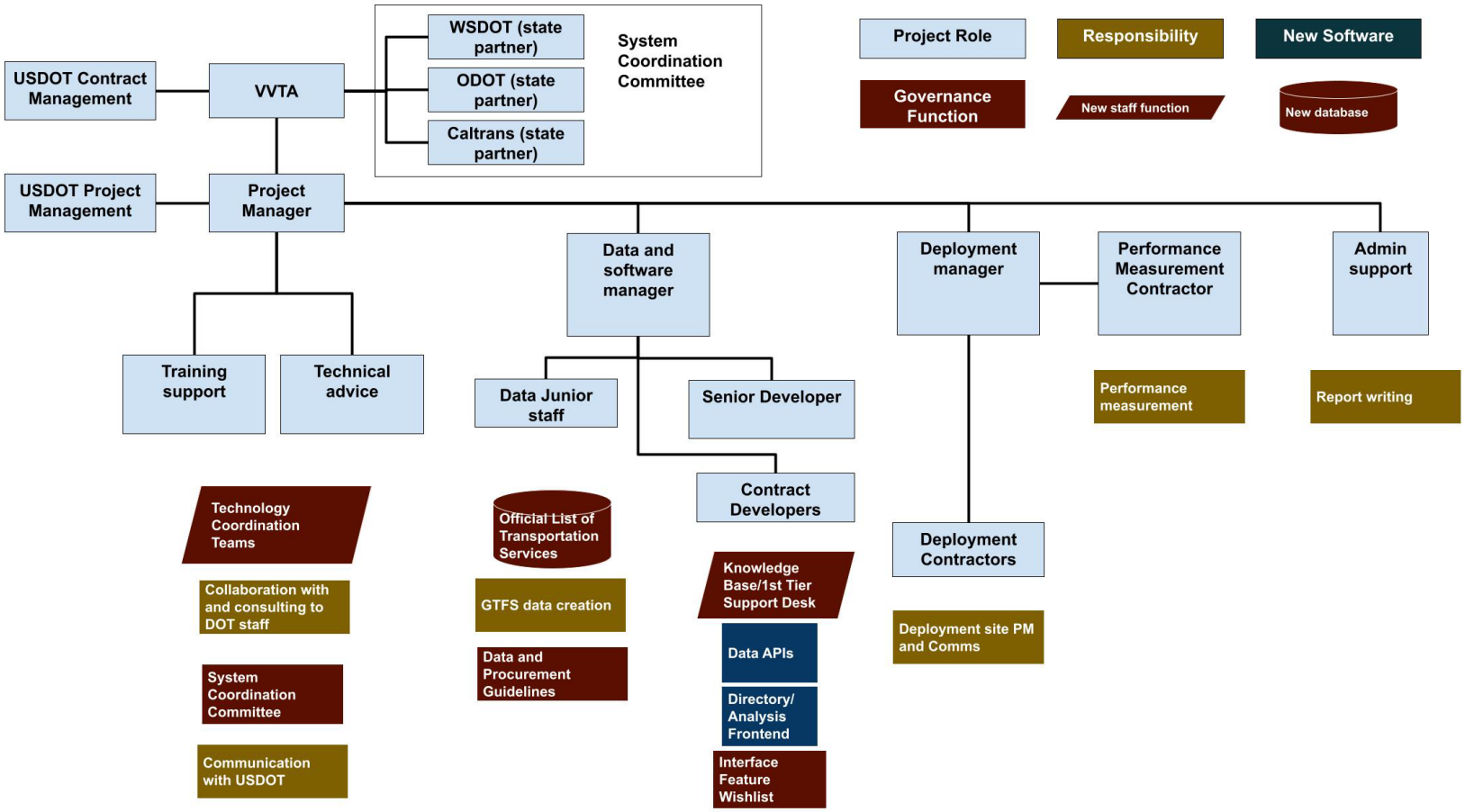
- Deployment Contractors – these contractors report to the Deployments Manager and provide services relevant to specific local deployment sites.

- Performance Measurement Contractor – these contractors report to the Deployments Manager and own the collection and reporting of data as defined in the Performance Measurement and Evaluation Support Plan (PMESP).

- Admin Support – this contractor reports to the Project Manager and supports the development of Systems Engineering Deliverables and project management activities.

An organizational chart showing the relationship between the above team members is in Figure 1 below. Beneath each team member are the system components from the proposed system (Figure 2) for which that team member is responsible.

Figure 1: Phase 2 and 3 Organizational Chart



2.1.2 Systems Engineering Deliverables

In Table 1 below are the major systems engineering deliverables which will be published during the project. A description of the deliverable along with the expected delivery date is provided. Due to the nature of the management approach described in section 2.2 of this report, Phase 2 and 3 deliverables are sometimes expected to be delivered subsequent to their traditional timeframe within a systems engineering project.

Table 1: Systems Engineering Deliverables

Report Name	Expected Delivery Date	Description	Link to Report (if published)
Concept of Operations	June 2021	The Concept of Operations identifies the user needs identified during research and a concept of the proposed system to be deployed in order to meet those needs. This report was drafted during Phase 1 of the project.	https://rosap.ntl.bts.gov/view/dot/58186
System Requirement Specification	October 2021	The System Requirement Specification details the high-level requirements the system is expected to fulfill. This report was drafted during Phase 1 of the project.	https://rosap.ntl.bts.gov/view/dot/60130
Systems Engineering Management Plan	January 2022	The Systems Engineering Management Plan describes the management approach which will be used to deploy the system. This report was drafted during Phase 1 of the project.	

Report Name	Expected Delivery Date	Description	Link to Report (if published)
System Architecture Document	June 2023	The System Architecture Document identifies the manner in which different components of the system interact and the structure of each component. This report will be drafted after the halfway point of Phase 2 and will refer to component-level architecture documentation.	
System Design Document	September 2023	The System Design Document specifies the major design choices made for each system component, and identifies code-level and process-level methodologies for meeting the system requirements. This report will be drafted after the halfway point of Phase 2 and will refer to component-level design documentation.	
Operational Readiness Plan	March 2024	The Operational Readiness Plan will overview the tests performed on the system component to ensure that the system meets the proposed system requirements. This report will be drafted near the end of Phase 2 and will refer to previous tests or to those planned during the remainder of the project.	

Report Name	Expected Delivery Date	Description	Link to Report (if published)
Comprehensive Maintenance and Operations Plan	April 2024	The Comprehensive Maintenance and Operations Plan will be a compendium document of architecture, design, and complete process documentations which will contribute to the operations of the system during Phase 3.	
Comprehensive Transition Plan	September 2025	The Comprehensive Transition Plan will describe the organizational and management process by which the system components will be transferred to a long-term operational and maintenance plan that does not rely on federal funding.	

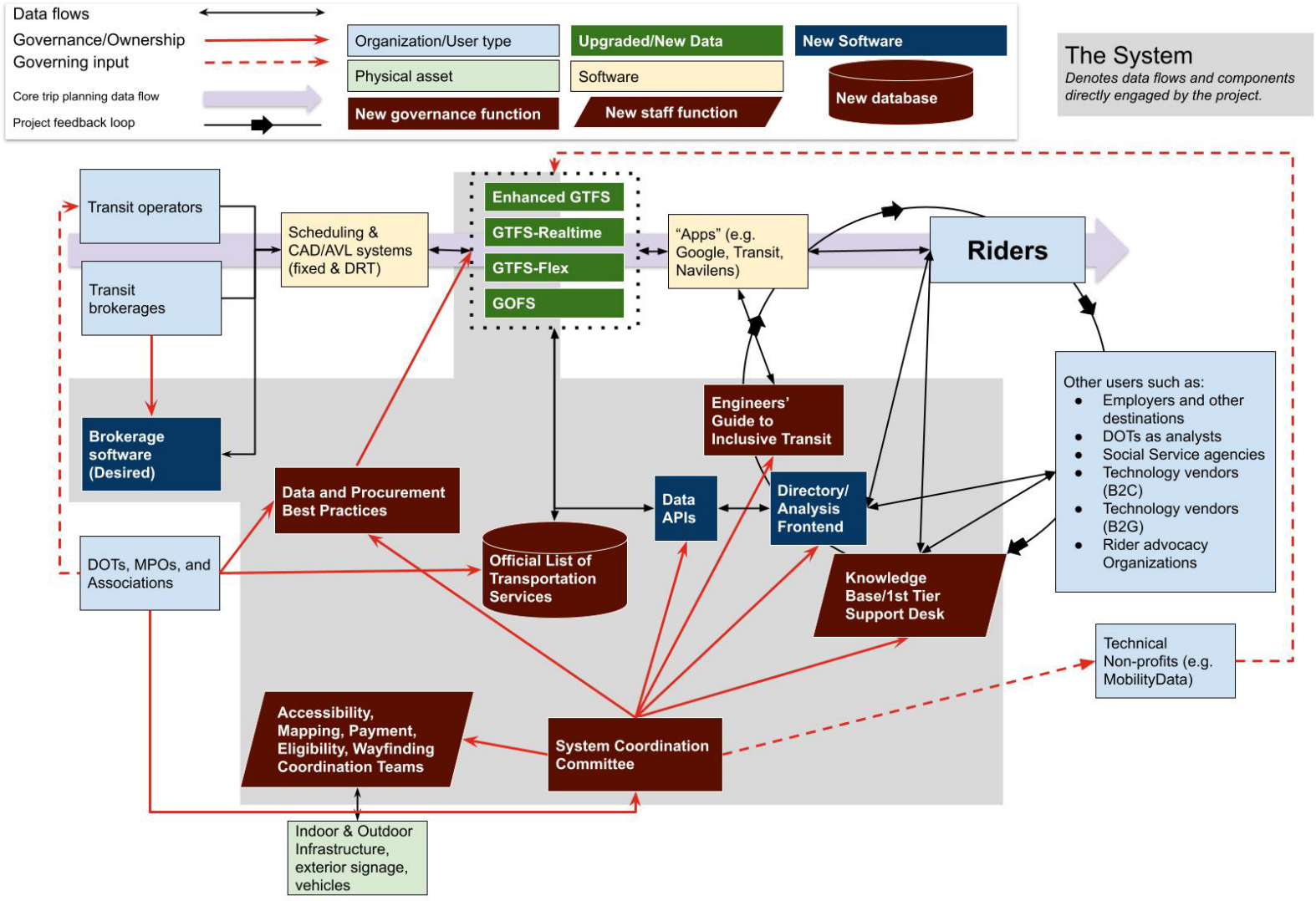
2.1.3 System Overview

The CALACT ITS4US project will create a system of technology infrastructure that coordinates organizations across the three-state region of California, Oregon, and Washington. The purpose of the system created through this project will be a new level of equitable technology service available to all transit operators and other rideshare providers in the region. Easy access to high quality trip planning will be more available to riders with disabilities, rural and low-income riders, those with limited-English proficiency, and veterans. These riders will be able to plan their trip, book their seat, and coordinate payment for their ride, even if that ride includes ADA paratransit, a rural dial-a-ride service, or a local community transportation non-profit serving rides to veterans. By connecting this demand-responsive trip planning into current fixed route trip planning, the full public transportation network will become available to riders from these underserved communities, and the network available to current fixed route riders will be expanded. The combined outcome will be a seamless transit experience, at reduced cost to taxpayers and more effectively reported to the state DOTs.

Achieving this outcome will be a coordinated effort between transit agencies, DOTs, technology vendors, technical non-profits, trade associations, and technology companies. The project will augment the flow of data from transit operators to riders by developing a system of coordination between the state Departments of Transportation (DOTs) in the region, which maintains transit data quality and aggregates that data on an ongoing basis. The DOTs are the primary project

sponsors and will lead the SCC, which governs the content of procurement guidelines required and supported by each state DOT. After the initial development of General Transit Feed Specification (GTFS) data extensions by project partners, these guidelines will ensure that high-quality transit data continues to be available throughout the life of the system, which will be aggregated in a transit directory system based on official lists of transportation services maintained by each DOT. The transit directory system will provide basic information regarding transit services to all users, including riders as well as other parties such as social service agencies or employers that may need information regarding the transit available. The SCC will also administer functions to publish best practices for the development of rider applications, to coordinate accessibility, eligibility, payment, and wayfinding coordination between agencies, and to support a first-tier support desk function that helps all users interact with the directory system. The diagram below shows the proposed system components and how they interconnect. The proposed system, with additional detail and in larger font, is provided in Section 5.

Figure 2. Proposed System Diagram



2.1.4 System Constraints

This project proposes to pursue the promotion of standardized data based on data specifications within the three-state region of California, Oregon, and Washington, which apply to agencies outside the three state region, in some cases globally. In particular, there is a specific focus on promoting the adoption of GTFS and proposed extensions to that specification, which have not yet been officially adopted and which, if adopted, could be voluntarily complied with and used by mobile application vendors such as Google, Transit, Navilens and others. There is an existing governance process and licensing regime for the GTFS, which would be pursued by this project and by other parties, but would not necessarily result in the standardization of data according to the proposals sponsored by this project. These global conversations are an important series of operational policies and constraints which will not be detailed in this document, but which must be considered by the project.[2]

The proposed system would also be constrained by the budgets and staffing of transit operators. While the increase in costs of software and labor for the management of software should be minimal, as a result of much information to be standardized being already captured by currently utilized software systems, there would necessarily be some increased costs at least in the short-term for software vendors which would be passed down to agencies.

Finally, this proposed system makes the assumption that other state and local governmental parties, including some partners of the project which are currently sponsoring parallel regulatory and development projects—such as Cal-ITP being pursued by Caltrans, AIM and Mobility4All grant-funded projects being pursued by ODOT, GTFS and GTFS-flex development projects being pursued by WSDOT, and the GOFS working group being pursued by MobilityData—will continue and be at least partially successful in achieving their ends. While there are a large number of projects that the proposed system relies on, this fact is understood as a strength and an opportunity rather than only a constraint and risk. The large number of parallel development projects indicates strong interest in the proposed work and a demonstration of intent to collaborate by partner and many other organizations. The proposed system would increase the coordination of these projects and increase the efficiency of resources devoted to those projects and decrease the risk of project failures.

2.1.5 System Milestones/Decision Gates

Below is a description by each phase of the major system milestones and decision gates to be considered. At each decision gate the Project Manager will seek specific advice from and confirm the decision with the SCC.

[2] More information regarding the GTFS governance process can be found at https://github.com/google/transit/blob/master/gtfs/CHANGES.md

2.1.5.1 Phase 1 (2021)

Phase 1 has and will constitute a series of interacting reports which together describe the project plan for Phase 2 and 3 of the project. The major remaining decision gates are the development of the Integrated Complete Trip Deployment Plan and the submission of a response to the Notice of Funding Opportunity expected to be released by the USDOT.

2.1.5.2 Phase 2 (estimated 2022-23)

Phase 2 is the design and development phase of the project. Major milestones related to the design and development of the system which will be deployed in Phase 3 will be considered during Phase 2. Many of these milestones relate to the dependencies between software components of the system. These milestones thus constitute important procedural checkpoints during the project that will help to minimize schedule delays or cost overruns. Note that the total maximum cost of the design, development, testing, deployment, and operations of each individual system component is set within the project budget identified in the Integrated Complete Trip Deployment Plan. So, while the project does not have a set schedule of when each individual component will be developed and deployed, these milestones and the project budget serve as important guiderails to ongoing schedule planning and project resourcing.

Key Phase 2 milestones include:

- Related to the Official List
    - Finalization of the Official List architecture
        - Delivery timeframe: 1 month after Phase 2 start
    - Finalization of the Official List design
        - Delivery timeframe: 2 months after Phase 2 start
    - Finalization of the Official List testing plan
        - Delivery timeframe: 3 months after Phase 2 start
- Related to the Data APIs
    - Finalization of Data APIs architecture
        - Delivery timeframe: 2 months after Phase 2 start
    - Finalization of Data APIs design
        - Delivery timeframe: 3 months after Phase 2 start
    - Finalization of Data APIs testing plan
        - Delivery timeframe: 6 months after Phase 2 start

    - Design will begin led by the Data and Software Manager with the support of the Senior Developer and a contractor on the current deployment team. Based on the design process, an RFP will be published by the Project Manager based on the design defined by the Data and Software Manager to find a contractor with other skills and experience depending on the outcome of the design process.
        - Decision timeframe (to initiate RFP process): 4 months after Phase 2 start

- Related to the Directory/Analysis Frontend.
    - Finalization of Directory/Analysis Frontend architecture and design.
        - Delivery timeframe: 8 months after Phase 2 start
    - Finalization of Directory/Analysis Frontend testing plan.
        - Delivery timeframe: 12 months after Phase 2 start
    - After scope and budget are set either a current team development partner will be assigned the development work or an RFP will be published to find a contractor with other skills and experience.
        - Decision timeframe: 10 months after Phase 2 start

- Related to the 1st Tier Support Desk.
    - Finalization of 1st Tier Support Desk architecture.
        - Delivery timeframe: 10 months after Phase 2 start
    - Finalization of 1st Tier Support Desk design.
        - Delivery timeframe: 12 months after Phase 2 start
    - Finalization of 1st Tier Support Desk testing plan.
        - Delivery timeframe: 12 months after Phase 2 start
    - After scope and budget are set either a current team development partner will perform the design and development work or an RFP will be published to find a contractor with other skills and experience.
        - Decision timeframe: 12 months after Phase 2 start

- Related to the Brokerage.
    - The scope and budget of the Brokerage must be clarified after final costs of other software products are determined. This decision point may determine that there is no budget available for the design and development of the Brokerage.

        - Decision timeframe: 14 months after Phase 2 start

    - After scope and budget are set either a current team development partner will perform the design and development work or an RFP will be published to find a contractor with other skills and experience. This decision will not be required if the previous decision point determines that there is no budget available for the Brokerage.

        - Decision timeframe: 18 months after Phase 2 start

- The identification of a contractor for providing system-compliant demand responsive transit booking software as a service.

    - The selection of a vendor for providing this software application within Deployment Site 3 will be performed through a procurement process in partnership with agencies in that deployment site.

        - Decision timeframe: 9 months after Phase 2 start

2.1.5.3 Phase 3 (estimated 2024-25)

Phase 3 is the deployment and evaluation phase of the project. Major milestones related to the deployment and evaluation of the system which will take place during Phase 3 include:

- Finalization of the long-term governance body to maintain the system after Phase 3.

    - During Phase 3 deployment, the governance framework can be underdevelopment, but upon the completion of Phase 3 that system must be fully active and providing ongoing maintenance of the system. The exact technical form of the long-term governance framework must therefore be determined prior to the end of Phase 3.

        - Decision timeframe: 12 months after Phase 3 start.

2.1.6 Standardized Processes

The CALACT ITS4US project is an incremental, iterative systems engineering effort, in which

- the system being developed is meant to impact software components that are explicitly outside the system (scheduling, dispatching, and rider application systems);

- the geographical scope of the system is expansive and changes over time; and

- the resources and stakeholder needs are shifting and cannot be strictly scheduled or predicted.

For these reasons the systems engineering process will be extensively borrowed from and used to organize project work, but will also be adapted extensively. Precise standards including

ISO/IEC/IEEE 15288.1, INCOSE SE Handbook, CMMI, ISO/IEC 90003[3] and others will be referenced but not always adhered to. This Systems Engineering Management plan and the Phase 2 project Management Plan will be tailored to fit the practical needs of the system design, development, deployment, and maintenance.

This project will engage with the standards development process related to the GTFS. GTFS is governed by its community members without restrictions on community membership. All changes to GTFS are made by consensus, with the necessity of having an active public producer and consumer of a proposed extension prior to a vote being called.[4] A non-profit organization, MobilityData, which is also a partner to the CALACT ITS4US project, provides unofficial stewardship of the GTFS, including the maintenance of the site at http://gtfs.org/ and the hosting of community workshops regarding potential changes and clarifications to the specification.

The CALACT ITS4US process, while it will adapt to a systems engineering framework and will only use specifically "Agile" methodologies in the context of software development (see section 3), will approach its work through an Agile philosophy as it is described by federal agency 18F:

> *Agile is not a checklist, or a methodology, or a series of rituals. Agile is a way of thinking and a way of attacking problems. Embrace mistakes, learn, and keep trying. Mess up and learn again and again and again. Cut your losses. Fail forward fast. It's okay. …*
>
> ***That** is Agile.*[5]

This project team does not believe that there is an applicable standardized process or framework available that perfectly fits the goals set for and resources available for the project. Rather than forcing the project into a specific management framework, the project team will minimize

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[3] This is a technical citation that includes the following acronyms:

CMMI – Capability Maturity Model Integration

IEC – International Electrotechnical Commission

IEEE - Institute of Electrical and Electronics Engineers

INCOSE - International Council on Systems Engineering

ISO – International Organization for Standardization

[4] More information can be found at https://developers.google.com/transit/gtfs/guides/changes-overview

[5] https://agile.18f.gov/agile-is-something-you-are/

commitment to specific project management styles or templated report frameworks, and perform the work that is in the estimation of the team and SCC, most likely to lead to project success and replicability.

The core elements of process are described in subsequent sections. All processes are subject to the team structure and hierarchy described in Section 2.1.1 above. The manager who owns each component as described in section 2.1.1 is the only individual allowed to determine systems engineering decisions during the course of the project. They will also necessarily communicate determinations made to other team members affected by that decision. Any decision relating to a change in scope will need to be submitted by the Project Manager to the full SCC for consideration and approval. The Project Manager will also periodically, at least once per year during the project including once within two months before the initiation of Phase 3, review the remaining scope and budget with the SCC and accept suggestions for alterations in budget allocation.

2.1.7 Defect/Discrepancy Processes and Configuration Management

Defects and discrepancies and the processes meant to address them will be managed through a Project Management Software system which allows the key persons on the project to identify specific defects based on information collected from partners, stakeholders, or internal review, and track the resolution of that defect. These defects and discrepancies will be processed through a general configuration management approach that controls system changes and ensures the stability of interfaces between system components. Software components will have additional procedures in place, to be discussed in Section 3. Non-software components will be managed directly by either the PML, SEL, or DL who will track specific defects or discrepancies, determine whether and how they shall be addressed, and assign the tasks necessary to resolve.

The project is designed by continually receive feedback from stakeholders, which will be collected and incorporated into issues within the Project Management Software system by the key personnel in charge of the relevant system component. For example, the 1st Tier Support Desk may receive rider complaints relevant to the Data Guidelines or Interface Feature Wishlist. Alternatively, the Deployment Manager (DL) may receive feedback from within a deployment site regarding the functions of the 1st Tier Support Desk and report the issue to the Data and Software Manager (SEL) for incorporation into that system. There will also be structured communications with transit operators, software vendors, and public organizations (e.g., presentations at conferences, or engagements through the Technology Coordination Teams) that will identify defects or new system requirements which should be incorporated into the system.

For any defect or other system change, there will be a simple but strictly defined process that will ensure the change is tracked and resolved in a fashion that maintains the overall functionality of the system. There will be no strict timeframe set on the reporting of defects or new system requirements and resolution of those defects for non-software components, but the following steps will always apply:

- the key personnel in charge of the component must confirm the issue
- the issue must be logged in the Project Management Software

- only the manager in charge of the component is allowed to confirm the issue resolved within the Project Management Software

- upon resolution of an issue, if the action requires the change of earlier reports (as in the identification of a new system requirement), the manager in charge of the component will create an issue for the reporting lead to edit and republish previous reports as needed.

A key aspect of this process is that it will be integrated with the ongoing development processes of the system. Each system component will not just be maintained, but will continue to evolve after initial deployment. Defects as well as improvements will be linked to system requirements that will be fulfilled by changes to the system at a later development stage. Software processes will follow an Agile development process with defined sprint timelines, as described in Section 3. Other system components will not follow an Agile process, but upon the collection of system requirements needing to be integrated into the operating system, a shortened and informal systems engineering development process will be used to confirm the user needs related to system requirements, develop, validate, and deploy the system adjustment. Validation processes will be discussed in Section 2.2.7 below.

2.2 Systems Engineering Technical Processes

2.2.1 User Needs Processes

The project developed the User Needs which are described in full in the Concept of Operations through an iterative design and research project collaborating with stakeholders from multiple stakeholder groups. A full description of this process can be found in the User Needs Identification and Requirements Planning report Section 2.

2.2.2 Requirements Processes

The project developed the User Needs, described in full in the Concept of Operations, through an iterative design and research project collaborating with stakeholders from multiple stakeholder groups. A full description of this process can be found in the User Needs Identification and Requirements Planning report Section 3.

2.2.3 Architecture and Interface Development Processes

The architecture and interface development process will iteratively produce a system architecture that accomplishes the critical components of a standard Systems Architecture Document (SAD) within a work plan that matches the evolving nature of a market-based intergovernmental coordination plan. Each component of the system will have its own architecture document produced in a simple, shared-document format. Those documents will evolve and be updated in the course of the ongoing development of each system component. Delivery of a “final” architecture for each project component will be staggered throughout Phase 2, and architectures will continue to evolve after initial delivery. The architecture for each individual component will be relatively simple and consist primarily of brief written text and diagrams. No special tooling will be utilized to develop the systems architecture.

A miniature system architecture walkthrough will take place for each system component after delivery of the final architecture document for the corresponding component, held online and lasting 1 to 3 hours. After the completion of all individual component walkthroughs, subsequent to design and development having begun or even been completed for some of the system components, a combined SAD will be developed and a miniature system architecture walkthrough convened for the overall system architecture. Feedback will be incorporated with consideration for what should continue to evolve moving forward.

The system architecture documentation will identify for each component the interfaces between that component and other components. This will include a variety of types of interfaces at appropriate levels of specification.

- Technology-assisted human interfaces: many of our system components are governance bodies, documents, and staff functionalities which require human communications rather than automated communications in order to exchange information between systems. These “human interfaces” (in other words, connections between systems that require person-to-person communication) will be defined by the message types, partner responsibilities, and communication needs.

- Data interfaces: some interfaces between system components will depend upon particular data standards or software data connections, which will be identified in the Standards Plan or the Interface Control Document portion of the SAD.

The intention of the system design is to evolve rather than simply be maintained over the system life cycle, so configuration management will integral to the systems engineering process. Further, the architecture of the proposed system will be a high-level representation of the key functional operations of the system and so should not change frequently. Therefore, unlike the design documents, all SAD changes will be reviewed and authorized by the Project Manager in addition to the manager in charge of that project component. This confirmation of architecture changes will supplement the configuration management process described in Section 2.1.7. Thus, all system architecture changes affecting interfaces between system components will be reviewed by both the Data and Software Manager as well as the Project Manager.

2.2.4 Design Processes

The final System Design Document (SDD) will describe exactly what subcomponent technologies are included within each system component, what process or infrastructure connects, what needs to be custom developed and the technical work that development will consist of, and which system requirements need to be accounted for by each subcomponent technology. Like the SAD, the SDD will be developed iteratively and only be fully aggregated into a single formal document after each of the individual system components has been designed, developed, and in some cases deployed. A component level design document will provide for the required information in the final SDD, but will be maintained in an easily editable format until incorporation into the final SDD. This document will specifically trace the subcomponent technologies to be used to individual system requirements, and identify any particular pre-existing open-source code to be integrated into the system or off-the-shelf products to be purchased for the system.

A miniature system design walkthrough will take place for each system component after delivery of the final design document for the corresponding component, held online and lasting 1 to 3 hours. After the completion of all individual component walkthroughs, subsequent to design and development having begun or even been completed for some of the system components, a combined system design will be developed and a miniature system design walkthrough convened for the overall system design. Feedback will be incorporated with consideration for what should continue to evolve moving forward.

System design decisions will be not only led but also confirmed by the manager of the system component in question (usually the Data and Software Manager/SEL, based on role descriptions in Section 2.1.1). The Senior Developer, Data Junior Staff, and Software contractors will be available to assist and advice on design decisions, as will the Project Manager and other project partners. System users will be consulted during design decision making through user testing of software components, and by receiving feedback from operators during deployment site outreach. While configuration management processes for component design will require the confirmation of the component manager, the confirmation of the Project Manager will not be required (as it is for architecture changes), unless the design change affects project budget, interactions with other system components, or other considerations under the purview of the Project Manager.

2.2.5 Development Processes

Software development processes for the project will follow an Agile approach which will be detailed in Section 3. This section will discuss the development of the non-software components of the project, and discuss the project approach to providing open-source software.

The non-software components of the system include

- A governance body
- Published documents
- Manually maintained databases
- Staffed functionalities

Each of these will be developed through distinct approaches.

2.2.5.1 Governance body

The governance body to be developed through the project is the governance body of the project: the SCC. It consists of communications processes between the state DOTs and a to-be-developed intergovernmental agreement between those parties which enables the ongoing collaboration on shared projects including the dedication of staffing and funds. The Project Manager will be the product owner of the SCC, and will work with DOT representatives to establish effective communications patterns and develop the intergovernmental agreement. The Project Manager and SCC will internally set interim deadlines for each stage of development of the SCC based on the requirements of those agencies determined during the course of the project.

2.2.5.2 Published documents

Two system components are documents or sets of documents which must be published for use by various potential consumers. These are the Data and Procurement Guidelines and the Engineers' Guide to Inclusive Transit. The Data and Software Manager will be the product owner for each of these system components. The architecture and design documentation for these components will specify audience, methods, format, editing processes, feedback collection processes, and publication processes, and whether any pre-existing documents will be used as a starting place or incorporated into the document collections. Development of these resources will consist drafting of exact guidelines and other documentation, as well as the development of the media channels through which the documentation will be shared (i.e., pages of product website, or another website, creation of outreach materials and distribution lists, social media accounts, etc.). This development will be managed by the Data and Software Manager through multiple iterations of the development process, based on the user needs and system requirements to be met by each version of the published document.

2.2.5.3 Manually maintained databases

There are multiple databases to be developed and maintained by the system, generally of two types: 1) official lists of transportation services and 2) lists of technology coordination projects pertaining to specific areas of concern.

The official lists of transportation services together are a system component which identifies the transit services in the three-state region and their relevant open data feeds for ingestion by the Data APIs. It is expected that each state DOT will lead the development and maintenance of the lists within each state, according to design specifications set by the project. Initial DOT lists will not need to be complete as the lists will be continuously updated with new data as it becomes available. Based on the schema, editing methods, and procedural requirements defined by the project, the DOTs will publish a list early in Phase 2 based on the transit services confirmed at that time. Maintenance processes will be described in Section 2.2.8 below.

The technology coordination teams will be described more fully in Section 2.2.5.4. below but will also consist of manually maintained database, consisting of lists of technology projects and contact information regarding those projects. These databases will be relatively simple, and unlike the official lists of transportation services it will not be important for the schema and publication processes pertaining to these lists to be static over time. The development and maintenance of these lists will begin immediately with the initiation of Phase 2 and design will generally consist of the maintenance of documentation explaining the layout of these lists and maintenance processes.

2.2.5.4 Staff functionalities

The proposed system consists in part of system components which are staffed by employees and contractors with the capacity to provide services to project users and stakeholders. These systems are the technology coordination teams and the 1st tier support desk (the latter of which has a significant software subcomponent as well). As labor-based services the supply of labor is the overwhelmingly significant constraint on these system components. Unlike with software, data, and governance components, where the design and development of the components constricts operations to certain functionalities, these staffed components can very easily change

their design during maintenance by simply doing other things with the available labor. For this reason, staffed functionalities will begin operations after minimal design and development time, especially the technology coordination teams.

The technology coordination team staff will maintain the lists of technology projects (see above Section 2.2.5.3) and provide technical support to transit operators, DOTs, and other stakeholders in implementing systems that provide open data according to the data and procurement guidelines and systems that support better regional technology coordination. The design and development process will define communications procedures, but once drafted those procedures will immediately be put into practice both reactively and proactively. Reactively the technology coordination teams will respond to requests from project partners. Proactively the teams will maintain a list of priorities and a light, flexible calendar that identifies opportunities and strategies to enhance technology coordination to support the goals of the project.

The 1st Tier Support Desk provides answers to rider questions in a conversational format. More so than the technology coordination teams, efficient labor management practices and having appropriate software tools to support that efficiency will be major constraints on system effectiveness. Additionally, it will be critical to define clearly, in coordination with the outreach plan, the channels through which and times when riders can request support, and what staff will be provided by the project or by the operator in order to respond to those report requests. Consequently, there will be a greater emphasis on the design and development of the 1st Tier Support Desk processes prior to operations, but the initial design and approach to be developed may be small in scope and answer these design questions in the most conservative way possible to limit the risk of the first deployment and better identify specific rider needs. Finally, the 1st Tier Support Desk will rely on other system components (e.g. Data APIs) and be highly localized (operating within Deployment Site 3 only), so design and development of this system component will take place after other system components have begun operation, during the second year of Phase 2. The software components of the 1st Tier Support Desk will be developed by the Agile team, described in Section 3.

2.2.5.5 Open-source software development

The CALACT ITS4US project will follow the following guidelines for the development of software code with regard to licensing and sharing of source code.

All newly developed software applications and libraries will be developed and released under open software licenses. New features and modifications to existing software applications (which will also be open source) will be licensed under the existing application license.

In the Phase 2 design process specific open-source software licenses will be proposed based on an understanding of the role of the application in furthering the sustainability of a more interoperable ecosystem. The SCC will adopt a strategic approach to selecting artifact and software licenses to be documented in a decision tree.

Regardless of the license applied to software applications, applications can and should support an interoperable ecosystem by (a) consuming and publishing data using open standards (b) contributing to the publishing of open data in open formats. All software applications used or

promoted by the project will be expected to comply with the MobilityData Interoperability Principles[6].

Additional coordination approaches and code maintenance practices may be adopted for specific software applications developed and enhanced by the project. When effective code contribution and maintenance practices are established within an open-source community, and it is an option for the project staff to participate directly within those established practices, such practices will be followed. If no such established practices exist, the project team will establish appropriate code maintenance processes including versioning of the code repository and limitations on contributor access, etc.

Newly developed code will have code storage and distribution policies set based on a decision tree similar to or part of the licensing decision tree described above. All code developed or enhanced by the project will stored in an accessible repository[7] and be submitted to the USDOT and shared with other relevant project stakeholders.

Specific plans for additional code contributions back to established open-source code repositories will be approached on a case by case basis. The project will lean towards greater community participation when adopting existing code, and will make every reasonable effort to provide developed code back to the open-source repository when those contributions would be valuable or are required by the existing license.

The software applications to be developed by the project which are expected to be open source are in the following list.

- Data APIs
- Directory/Analysis Frontend
- 1st Tier Support Desk
- Three additional project components may include open-source software technologies:
    - Official lists: These are databases of transit operator metadata, but could potentially include some software source code as well.
    - Data and Procurement Guidelines: This is written, human readable content, but may be published through a website which would require custom developed software.

[6] https://www.interoperablemobility.org/

[7] Planned to be GitHub. See section 3.6 below.

- Engineers' Guide to Inclusive Transit: This is written, human readable content, but may be published through a website which would require custom developed software.

2.2.6 Implementation, Integration and Verification Processes

As described above, especially in Section 2.1.7 regarding management of defects, which will be approached in a fashion similar to the ongoing evolution of system components in which new features are added, the system will not be designed, then developed, then deployed at one particular time. Instead, various system components will be designed, developed, and deployed at different times. After deployment, which for some components will happen prior to the design of some other components, components will continue to be changed through the identification of new system requirements or defects in the defined approach to meet the system requirements.

For this reason, implementation, integration, and verification processes will be performed at different times for each system component, and the verification process will often involvement deployment and testing with users in a pilot or live environment. This is true for both software and non-software components of the project, although software development will also be subject to testing within the Agile process described in Section 3, and all software applications will be subject to integration testing and regression testing processes at each release. Testing will follow the approach specified for each component in the subsections below, along with information about the expected timeframe of testing and first deployment (defined in parentheses e.g., "signing of first intergovernmental agreement"). These expected timeframes are not required, and may be adjusted during the course of the project. Some of these timeframes are however related to key delivery milestones from Section 2.1.5 above, which are more critical as a result of identified software dependencies.

The type of testing taking place within this project is often not related to software or hardware, and based on the Safety Management Plan drafted during Phase 1 of the project, there are not expected to be safety risks during deployment that justify an extensive safety management approach. Thus the verification will typically take place by inspection of drafted resources and procedural documents, or consist of gathering feedback from project stakeholders in a structured environment. System and component tests will be performed and tracked during the course of Phase 2, with a miniature testing plan developed for each component at different times, and many tests performed prior to the testing plans for all components being fully developed. Plans and results from those tests will be integrated into a System Test Plan (STP) which will contain the information related to all system tests.

After the submission of the System Test Plan, the Operational Readiness Plan will be developed including a process to verify each of the Operational Scenarios identified within the ConOps is adequately supported by the system. The proposed verification processes in the Operational Readiness Plan will be presented in a remote, half-day walkthrough at least three months prior to the end of Phase 2. This walkthrough will yield further feedback which will be incorporated into the final Operational Readiness Testing Schedule. These verification processes will be performed by the project team under the direction of the Project Manager. The results of these processes will be showcased in an Operational Readiness Demonstration, which will be a public, online presentation of the user-facing functionalities of the system.

2.2.6.1 System Coordination Committee

As the governance body of the system and also a system component, the SCC will be immediately deployed at the beginning of Phase 2, at the same time that formal architecture and design work for the component begins (although much of that work has been performed during Phase 1 of the project). There will be no formal testing of the SCC but the design of the committee will change over time as it incorporates feedback received regarding the project and SCC activities.

Anticipated timeframe of first testing and deployment (signing of first intergovernmental agreement): 18 months after initiation of Phase 2.

2.2.6.2 Data and Procurement Guidelines

The testing process for the guidelines will primarily include stakeholder outreach to transit agencies and software providers, to present a draft form of the guidelines and receive feedback. See the Outreach Plan section 4.2 for more information regarding the outreach processes that will support the collection of feedback.

Anticipated timeframe of first testing and deployment (first publication on public website): 6 months after initiation of Phase 2.

2.2.6.3 Engineers' Guide to Inclusive Transit

The testing process for the Guide will primarily include stakeholder outreach to transit agencies, software providers, and riders, to present a draft form of the Guide and receive feedback. See the Outreach Plan section 4.2 for more information regarding the outreach processes that will support the collection of feedback.

Anticipated timeframe of first testing and deployment (first publication on public website): 15 months after initiation of Phase 2.

2.2.6.4 Official List of Transportation Services

The testing process for the Official List of Transportation Services will be performed through the development of the Data APIs. The Data APIs will be a consuming application of data from the Official Lists. The use of data from the Official List within the Data APIs will serve to identify defects within the Official Lists, through the development of integration tests which identify unexpected data changes within those lists.

Anticipated timeframe of first testing and deployment (first publication by a state DOT): 3 months after initiation of Phase 2.

2.2.6.5 Data APIs

The Data APIs will be tested through the Agile software development process to be described in section 3. Additionally, two other applications which will use the Data APIs will provide critical testing processes for the Data APIs through their development and deployment. The Directory/Analysis Frontend and the deployment site 2 website (to be developed by a local agency within that deployment site) will call endpoints from the Data APIs and provide feedback

to the project team. The deployment of those applications will provide real users for the Data APIs to confirm the usability of the software.

Anticipated timeframe of first testing and deployment (first release allowing testing and use by external development parties): 8 months after initiation of Phase 2.

2.2.6.6 Directory/Analysis Frontend

The Directory/Analysis Frontend is a relatively minor system component and will receive a very basic testing process, such as manual reviews of the agencies listed and data presented by members of the Data Junior Staff. Because the exact use cases of the Directory/Analysis Frontend will be undefined until after the exact budget is set for the application late during the first year of Phase 2 (see above Section 2.5.1.2), the appropriate testing processes also cannot be defined until after that time.

Anticipated timeframe of first testing and deployment (launch of publicly accessible website): 18 months after initiation of Phase 2.

2.2.6.7 1st Tier Support Desk

Testing of the 1st Tier Support Desk will consist of confirming that software tools to support certain communications channels provide an effective user experience for the rider seeking support and also integrate as needed into the backend support desk technology used by the project team. Testing will generally be performed on a channel-by-channel basis. Because different channels will be released sequentially, it is likely that multiple testing processes will be performed and the relevant channel deployed prior to beginning development on the next planned channel.

Anticipated timeframe of first testing and deployment (first communication with rider): 21 months after initiation of Phase 2.

2.2.6.8 Technology Coordination Teams

There will be no formal testing of the technology coordination teams, but similar to the SCC, this staff functionality will be initiated quickly as described in section 2.2.5.4 above. Feedback will be consistently incorporated based on the activities pursued and the needs which arise from project partners and incorporated into design documents as system processes change.

Anticipated timeframe of first testing and deployment (first communication with agency): 3 months after initiation of Phase 2.

2.2.6.9 Overall system testing

Because each component of the system operates independently, and integrated components will be tested through the deployed integration of those components, there is no need perform an overall system test separate from the validation process. Upon the testing and deployment of all components, the test results summaries for each component will be updated and incorporated into a retroactive Operational Readiness Plan that describes the tests which have occurred prior to system validation.

2.2.7 Validation Processes

In final system validation prior to the beginning of Phase 3, the project team will draft a “design fulfillment statement” for each system requirement to confirm the manner in which the system fulfills that system requirement, and which system requirements are fulfilled. These design fulfillment statements will be incorporated into the Operational Readiness Plan, referencing tests performed by the project as documented in the Operational Readiness Plan. This process will benchmark the status of the system at the end of Phase 2 against the original system requirements specified during Phase 1.

2.2.8 Operations and Maintenance Processes

Depending on the system component, different operations and maintenance processes will govern ongoing work to ensure the component performs as expected and continues to change in response to feedback from system users and stakeholders. The central process that will govern all operations and maintenance work will be the issue resolution process described in Section 2.1.6. Beyond the process of incorporating feedback into fixes and new features, each system component will have Standard Operating Procedures that identify recurring activities as well as responses to known operational scenarios to be encountered. These operating procedures will be incorporated into a single Comprehensive Maintenance and Operations Plan (CMOP) prior to the end of Phase 2. The CMOP will exist as a living document in an online knowledge base or other website application that can be easily loaded, navigated, and edited by multiple users.

2.2.8.1 Governance body

The SCC will begin operations at the beginning of Phase 2 and will consistently be open to adjust its own processes as they are being finalized for the long-term through the creation of an intergovernmental agreement between the three states for the ongoing maintenance of the system. However, development of that long-term maintenance system will also continue through Phase 3. The Phase 3 Comprehensive Transition Plan will be the first document presenting a static, long-term vision of the SCC, and until that time it will be adjusted and maintained through action taken by the Project Manager with the consent of all members.

2.2.8.2 Published documents

The Data and Procurement Guidelines will each have two maintenance processes: 1) scheduled major updates and 2) simple clarifications and corrections. Scheduled major updates will be quarterly or annually and consist of significant changes to the content, published design, and outreach materials related to those components. These updates will be based on internal lessons learned and the continued progress of the project to adopt further structured stakeholder outreach and feedback collection. Simple clarifications and corrections will include actions taken as needed to correct typos or styling errors on the project websites containing the published documents.

2.2.8.3 Manually maintained databases

Each of the manually maintained databases will be maintained on an as needed basis by project or DOT staff. The technology coordination teams and DOTs will establish more precise internal procedures regarding the modes of maintenance during component design.

2.2.8.4 Staff functionalities

The staffed functional components of the project, the technology coordination teams and the 1st Tier Support Desk, will require ongoing assessment of issues being raised and resolved as well as work towards incorporating all identified system requirements. This will require ongoing maintenance through management activities, carried out by the project manager and the deployments manager, as well as the provision of training to support staff involved in these system components. These processes will begin immediately upon the deployment of these systems, even in partially developed form as described in section 2.2.5, and will be part of the routine process of collecting and implementing feedback regarding this system component described in Section 2.1.6.

2.2.9 Post Phase 3 Processes

The system is intended to continue functioning after Phase 3, at the same or an improved level of service as provided during the federally funded deployment. The long-term 'owner' of the system is not yet determined, and could be any of the three state DOTs involved in the project, another government entity, a non-profit (either existing or created for the purpose), or a model not yet known. The system should operate for at least an additional 5 years, but 10 or more years is likely. The data standards being supported by the system are expected to last for many years, and even if they cease to be used, new standards could be adopted by the proposed system.

The proposed system is intended to split the responsibilities of many important aspects of system maintenance across operators, vendors, and regulators, by coordinating many activities that are currently inefficient because of the lack of shared data standards. If successful, the result would be enhanced information for users, specifically the groups of underserved users identified by this project and institutional users such as the DOTs in their analysis role and rider advocacy groups, with a minimal increase in long-term operational costs for transit operators and software vendors. This outcome would rely on the long-term maintenance of all deployed system components. The required long-term maintenance cost of system components can be distinguished in three types as follows:

1. **Software hosting and maintenance**: This includes all costs required to continue providing the Data APIs and Directory/Analysis Frontend, and software components of the 1st Tier Support Desk. Some cash expense for this long-term maintenance cost is certain, due to the direct expense of hosting. Software maintenance and new development might require the purchase of development specialists, but might also be provided in kind by a project partner.

2. **Public resource maintenance**: Public resources such as the Engineers' Guide to Inclusive Transit and the Data and Procurement Best Practices will require minimal direct web hosting costs, as well as some time making at least occasional updates to account for changes in data specifications. It may also be required or advisable to periodically reach out to many stakeholders and collect feedback for more extensive updates. The labor for this work can likely be performed by state DOT employees, but could also sometimes require additional contracted services.

3. **Staffing and procedure maintenance**: The Technology Coordination Teams, System Coordination Committee, and 1st Tier Support Desk all require ongoing staffing. The magnitude of staffing to be provided could vary widely and be performed by different

organizations depending on the context. For example, in one state the DOT may provide technical assistance to operators, but in another state the transit association may take on this responsibility. Additionally, the 1st Tier Support Desk might be designed in a way such that a call center must be staffed by dedicated team members, or might be designed in a way such that the required labor can be provided by operator staff with other primary responsibilities.

The Project Manager will lead the development of a draft and final Comprehensive Transition Plan (CTP) to guide the activities of the system post deployment. This CTP will identify which organizations will fulfill each known responsibility, and also track key procedures of system operation for the handoff to those organization. The CTP will provide information management processes and other resources to ensure the successful long-term maintenance of the system.

3 Agile Process Application

This section describes the Agile processes through which software applications will be developed. It defines which components are subject to an Agile process and which Agile methodologies will be used, identifies the members and structure of the Agile team, and discusses details of the Agile process application such as the length of sprints and release process.

3.1 Systems/Subsystems/Components Using Agile Development

The CALACT ITS4US project will use Agile development methods in the development of software applications. As the component owner of these applications (see Section 2.1.1), the Data and Software Manager will be the Agile team lead and product owner (described in Section 3.3 below). There are at least three software applications expected to be subject to the development methods described in this section:

- Data APIs
- Directory/Analysis Frontend
- 1st Tier Support Desk
- Three additional project components may include software:
    - Official lists
    - Data and Procurement Guidelines
    - Engineers' Guide to Inclusive Transit

Each software component developed through this project will follow the same Agile development methodologies. We will use Agile methodologies as defined and implemented by 18F.[8] 18F's practices have modified some of the best software development practices in the private sector to be specific for governments, especially in regard to risk and inclusive design. The core components of this approach are an iterative cycle of (1) user-centered design (2) development

[8] See the complete list of 18F guides at https://18f.gsa.gov/guides/. 18F is an office of federal employees within the General Services Administration (GSA). More organizational info at https://18f.gsa.gov/about/.

(3) testing (4) deployment, and (5) feedback. Agile software development reduces the risk of failure and cost overruns in software projects.[9]

Accessibility is core to all services delivered by and on behalf of government agencies, the project team will adopt and implement appropriate accessible design practices to service the project's core users and meet state and federal guidelines.[10]

The methodologies described below will be applied through a sprint and meeting structure generally aligned with the Scrum framework. During each sprint (see Section 3.5, below) human-centered design methodologies[11] will be applied as required to define and meet the sprint objectives. In the subsections below are some of the specific methodologies the team expects will be deployed at different times during the project to support the successful completion of sprint tasks.

3.1.1 Stakeholder and User Interviews

A stakeholder interview or user interview is "a wide-spanning set of semi-structured interviews with anyone who has an interest in a project's success, including users."[12] During the architecture phase of a new component or feature, the Agile team may interview various stakeholders or users to put the system requirements into context and develop a practical understanding of user needs. The interviews will be lightly organized, using such tools as an interview checklist.

3.1.2 Journey Mapping

During the design stages the Agile team may use journey mapping to provide them with "a bird's-eye view of a service that helps them see the sequence of interactions that make up a user's experience including the complexity, successes, pain points, and emotions users experience" during system operations.[13] Journey mapping will support the key design choices that will have a powerful impact on the user experience, and allow for the development of a collaborative understanding of the solution to be developed among Agile team members.

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[9] see the 18F guide to de-risking software projects: https://derisking-guide.18f.gov/.

[10] The project will follow the accessibility guide at https://accessibility.18f.gov/. Additional resources which may be referenced in the pursuit of equitable and accessible technology investment include: LA Metros' equity framework for making project and policy decisions to impact software design, http://metro.legistar1.com/metro/attachments/dabba808-fdf7-4f71-8869-66f2f60d40c7.pdf; and National Rural Transit Assistance Program resources on accessibility, https://www.nationalrtap.org/Technology-Tools/Website-Builder/Support/Accessibility.

[11] The sections below draw from methodologies defined at https://methods.18f.gov/

[12] https://methods.18f.gov/discover/stakeholder-and-user-interviews/

[13] https://methods.18f.gov/decide/journey-mapping/

3.1.3 Task Flow Analysis

A Task Flow Analysis is "step-by-step analysis of how a user will interact with a system in order to reach a goal."[14] It identifies different possible actions taken by the user as well as what actions must be taken by the system, and presents an overview of those choices and actions in a solution-agnostic fashion. During the design and architecture phase, this process may help the Agile team identify particular points of interest, concern, or risk in the task flow.

3.1.4 User Scenarios

User Scenarios will adapt the operational scenarios and user needs identified within the ConOps to the Agile process and allow the Agile team to "a story about a user's interaction with your product, service, or website, focusing on the what, how, and why."[15] This methodology will be specifically useful for the Agile team in developing an understanding of the needs of specific underserved users of the system.

3.1.5 Wireframing

A wireframe is a "simple visual representation of a product or service interface." During the design and development stage, wireframing will help the Agile team make concrete specific interfaces that a user might interact with. This methodology will ensure that designs presented preference functionality over decoration.

3.1.6 Usability Testing

During usability testing, the Agile team will observe users "as they attempt to use a product or service while thinking out loud."[16] This approach will be important in the collection of feedback regarding software features during system testing. The project has a specific interest in supporting voice interfaces for conversational transit information and accessibility for users with vision disabilities and usability testing is an important step for these software interfaces in particular.[17]

[14] https://methods.18f.gov/decide/task-flow-analysis/

[15] https://methods.18f.gov/decide/user-scenarios/

[16] https://methods.18f.gov/validate/usability-testing/

[17] https://alistapart.com/article/usability-testing-for-voice-content/

3.1.7 Regression Testing

At each sprint, unit tests and regression tests will be designed and developed to support the ongoing maintenance of software applications by ensuring the continued operation of features delivered within the sprint.

3.2 Systems Engineering-Agile Integration

The Agile team will manage the following integration points between the systems engineering process and the Agile process.

- In defining Agile epics and user stories, system requirements will be included to describe features and define acceptance criteria for a story. This will allow for System Requirements to Epic/User Story Traceability.
- Epics will be used to group functional and thematic product releases. User stories will be pointed to help in estimating delivery timelines.
- Product release notes will publish updates for stakeholders in a timely, discrete, approachable way, while complementing robust reports that describe the entire system or system component.
- User stories will define acceptance criteria which will be used to perform user acceptance testing before deployment of new features.

3.3 Agile Team Roles

The software development teams will be “self-organizing teams with Empowered Product Owners” as described by 18F:

> *Agile teams are composed of peers who share ownership of the team’s work and decision-making processes. Self-organizing teams in Scrum are given ownership of their work process, their commitments, and their approach to meeting their commitments. Product Owner is the role in Scrum that represents the business and customer directly within the development team. The Product Owner must be empowered to make product decisions in response to feedback from stakeholders and customers. Taken together, a Scrum team has complete control over how it does its work and what work it does.*[18]

[18] See https://agile.18f.gov/agile-fundamentals/

Specific roles will not be assigned within the scrum team other than the Product Owner, although other roles such as Client and Stakeholder will be used to frame communications with other parties.[19] The Agile software development scrum team will generally consist of

- Data and Software Manager, Product Owner (in charge of sprint and release planning, see Section (3.5)
- Senior Software Developer
- Other members of the contract software development staff as needed on a component basis
- Other members of the contract Data Junior Staff as needed on a component basis
- *Concept being considered by project: define either the project manager or the deployments manager as the "client" for the purposes of the agile development team.*

The USDOT are stakeholders for the purpose of defining the relationship with the scrum team, and will be considered co-collaborators in the outcomes of the project. The Data and Software Manager will regularly join standing meetings between the USDOT and the project team in order to share progress and accept feedback. Stakeholders will be included throughout design and testing processes as appropriate to the specific methodologies being used (see subsections of Section 3.1 above).

3.4 Communities of Practice

The Agile team will connect with potential users of the software to be developed, especially with regard to the Data APIs, which will be used by government communities of practice related to open data usage. The project partner MobilityData supports conversations in many communities of practice related to transit data, and will support the identification of conversations in which the Agile team should engage. Engagement with communities of practice will also relate to internal software processes that support long-term usability, such as the adoption of standard practices for git hygiene.

3.5 Sprint and Release Planning

Sprint process and release planning will vary from component to component, but broadly the product owner will own the sprint release and planning process, leading story development, story prioritization and sprint planning meetings and sprint retrospectives. Continuous integration and continuous deployment will be essential, with integration tests being developed during each sprint and the software being deployed for users to the degree capable by the end of each sprint (even

[19] See https://agile.18f.gov/agile-lexicon/#roles

if only for testing). Sprint length will be determined before work commences, with a default assumed length of four-week sprints for most components.

Each sprint will include interactions with other project team members and stakeholders as are appropriate to both ensure the agile team has the information it needs to proceed efficiently and that other partners are aware of current development efforts. This will include the identification of standing meetings separate from sprint demonstrations to connect with other partners involved in software development efforts related to the Data APIs, including MobilityData, Cal-ITP, ODOT, and Hopelink.

Releases will be coordinated events with both the Project Manager and Deployments Manager as well as the Data and Software Manager in communication to ensure all system components continue to function as expected and the current status of system software components is understood by all management team members. Integration and regression tests managed by the agile team will provide automated validation of successful releases. After any release of the Data APIs, agile team members or other project management staff will conduct a review of dependent applications such as the Directory/Analysis Frontend, 1st Tier Support Desk, and Hopelink One Call One Click system.

Major releases of applications, such as public launches or deployments for testing by key stakeholders, will be coordinated with the overall system development schedule. Milestones for the first delivery of each system component can be found in Section 2.2.6 above.

3.6 Agile Development Tools

The following software tools will be used by the Agile team during the development process, among other tools later identified or specified.

- Sprint Planning Software: GitHub Projects
- Code Versioning & Hosting: GitHub
- Hosting: TBD by component
- Continuous Integration/ Continuous Development: GitHub Actions,
- Automated Testing: Cypress.io, LightHouse ADA Checker

We expect this list to expand and project needs are further defined. Broadly all access will be granted using least-privilege access, only those requiring access to accomplish essential tasks will have access. Given system components are being developed as open source, while administrative access may be limited, view access in most cases will be set to public.

3.7 Agile User Demonstrations

The Agile team will use stakeholder demonstrations, in line with the “demos not memos” vision of Agile development, in order to demonstrate system functionalities and integrate feedback into

future design and development plans. A demo will be held for some group of users at the end of each sprint (although at times that may be only one or two user representatives).

A key methodology of Agile we will be using extensively is usability testing, see Section 3.1.6 above. Usability testing of MVPs and new features will be required before release.

Additionally for each system component deployed we will implement a user-facing bug reporting process. Bug reports will be managed by the product owner for reproducing and prioritizing fixes as part of the sprint planning process. For the 1st Tier Support Desk this system will be the support desk software itself. For other system components, this may be a GitHub repository where issues can be logged, or an email contact to which issues should be sent. In general, no or minimal development will be necessary to implement user-facing bug reporting processes.

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

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