WSF Travel Wait Times Assessment Project

Concept of Operations

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WSDOT

ARCADIS

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List of Acronyms

Acronym	Term
ACL	Access Control List
ADA	Americans with Disabilities Act
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
AIS	Automatic Identification System
API	Application Programming Interface
CCTV	Closed-Circuit Television
CISA	Cybersecurity & Infrastructure Security Agency (CISA)
COI	Certificate of Inspection
ConOps	Concept of Operations
FAC	Ferry Advisory Committee
FHWA	Federal Highways Administration
ITS	Intelligent Transportation Systems
LDAP	LightweightDirectory Access Protocol
LOS	Level of Service
LRP	(WSF's 2040) Long Range Plan
MaaS	Mobility-as-a-Service
MFA	Multi-Factor Authentication
MOMS	Maintenance Online Management System
NIST	National Institute of Standards and Technology
PAM	Privileged Access Management
SME	Subject Matter Expert
TNC	Transportation Network Company
WAC	Washington Administrative Code
WSF	Washington State Ferries
WSDOT	Washington State Department of Transportation

01

Executive Summary

Figure 1: Puget Sound Project Area

1.1 Introduction

This Concept of Operations (ConOps) describes the user needs and operational context of a proposed Ferry Terminal Wait Time Traveler Information System. This ConOps was developed for Washington State Ferries as part of a grant awarded under the Advanced Transportation and Congestion Management Technologies Deployment program.

The Wait Time System will deliver actionable, real-time information about current and predicted ferry terminal wait times to travelers, providing them the information needed to make informed decisions about how and when to use the ferry system. The information travelers obtain from the Wait Time System will allow them to avoid congestion at the terminals, spend less time queuing up to board the vessels, and experience the benefits of greater control over their travel choices. The Wait Time System will also serve WSF stakeholders. Automated data collection and dissemination will reduce the burden on terminal staff to estimate wait times, allowing that staff to concentrate on core terminal operations. WSF Customer Service staff will receive more accurate information, more quickly, so they can more effectively provide traveler information to the region's travelers. Agency planners and other decision-makers will be able to rely on historical data to make more informed decisions about service planning and effective investments in ferry infrastructure and operations. ***Figure 1*** provides a graphical overview of the Puget Sound project area.

The vision for the Wait Time System is in alignment with WSF's operational goals of reducing terminal congestion, providing improved service to travelers, and reducing greenhouse gas emissions. The purpose of this ConOps is to communicate a clear understanding of user needs and to describe how the system will operate to fulfill those needs. The ConOps is written with a non-technical approach, easily understood by stakeholders not involved in the details of the project.

This document describes 'what' the system will do, but not 'how' the system will do it. The ConOps is generally unconstrained by cost and specific implementation details; therefore cost analysis and the development of detailed technical requirements is recommended before making final decisions to progress the concepts described here.

The intended audience for this document includes:

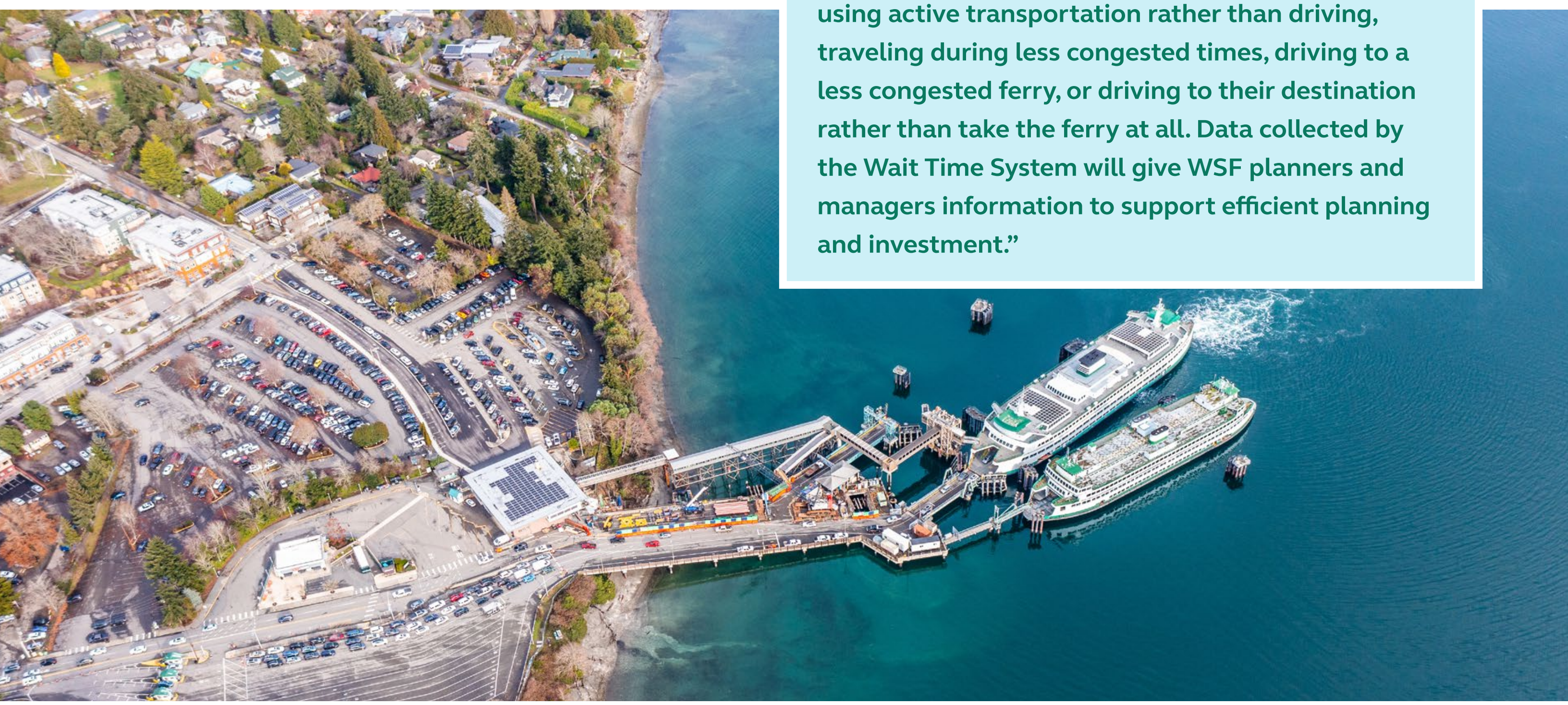
1. **WSDOT and WSF managers, planners and executive staff tasked with reviewing and approving the ConOps**
2. **WSF terminal, Customer Service and operational staff, to determine whether their needs have been adequately captured**
3. **A system integrator and solution providers who will create and support the Wait Time System based on the user needs and system concepts described in this document**
4. **Other public ferry agencies, to support effective planning to address commonly experienced operational and technical problems**

1.2 Vision, Goals, and Objectives

1.2.1 Vision

This ConOps is supported by a simple, central vision that serves as an overarching theme of this document, and is intended to guide design, development and operation of the system. Every task related to system deployment, and every required step of the systems engineering process will have this vision at its core:

"Ferry travelers will be able to access real-time wait time information, accurate and timely enough to make decisions in advance, and in the moment about how and when to travel. Accurate information supported by historical data and predictive modeling, will allow drivers to consider other options such as switching to other modes of travel, using active transportation rather than driving, traveling during less congested times, driving to a less congested ferry, or driving to their destination rather than take the ferry at all. Data collected by the Wait Time System will give WSF planners and managers information to support efficient planning and investment."



1.2.2 Goals

A project that seeks to deliver successful results requires that the sponsoring agency, relevant stakeholders, and developers of system documentation share a clear and achievable vision of how technology will support the system and solve the identified problems. The core source of project goals was derived from WSF's 2040 Long Range Plan. Additional goals were derived from stakeholder engagement where user needs and operational challenges were developed. An extensive review of relevant project documentation and evaluations provided input to help refine and find overlap with stakeholder input.

The goals of the Wait Time System are:

- ✔ **Advance the goals of the 2040 Long Range Plan**
- ✔ **Relieve congestion across the transportation network**
- ✔ **Improve efficiency at the terminals for staff**
- ✔ **Contribute to greenhouse gas reduction goals**
- ✔ **Improve the customer experience**

1.2.3 Objectives

Objectives provide measurable actions in the short term, to further the goals of the system and project. The goals established for the Wait Time System will be supported by objectives focused in three areas:

- ✔ **Data Collection**
- ✔ **Data Processing / Integration**
- ✔ **Data Dissemination / Traveler Information**

While goals are aspirational ideas to help guide the project, objectives tell what actions must be taken to achieve the goals. The objectives for the Wait Time System are:

1. Data Collection

- Devices / sensors will be installed at appropriate points to collect vehicle queue and classification data
- Roadside devices will detect travelers throughout their journey, from origin terminal to destination
- Leverage existing ITS infrastructure such as IP-based cameras operational at the terminals and on the approaches
- Use advanced video analytics to detect vehicles that cut into the established line

2. Data Processing / Integration

- System integrator will design an algorithm to ingest and process various data streams
- Calculate wait times based on vehicle queue data, vessel capacity, traffic congestion data
- Host database and processing efficiently in a cloud environment

3. Data Dissemination / Traveler Information

- Produce actionable traveler information for ferry customers
- The existing WSDOT mobile app and traveler information website will be the platform through which Wait Time System data is provided to travelers
- Traveler information and alerts will be disseminated via VMS where available

1.3 Use Cases

This ConOps is written from the perspective of the potential users of the system. Users have been identified in two general categories: **the public, i.e. ferry customers, and WSF agency staff.**

The Wait Time System will provide travelers with accurate, up-to-date wait time information that allows them to make informed travel decisions, contributing to a leveling of demand and reduced congestion throughout the system. Using an intuitive mobile interface, integrated with WSDOT's traveler information app, travelers such as local commuters, visitors and tourists, attendees of large special events, commercial vehicle drivers and others will see approximately how long they can expect to wait in a ferry terminal queue, and if they will make the next vessel. When conditions or congestion is such that they should not expect to make the next vessel, the system will tell them when the next boat arrives and if they can expect to board that boat.

WSF terminal operators currently need to turn their attention away from ticketing and other dock operations to visually assess the number of vehicles in line at the ferry approach, and estimate the wait time a driver can expect to experience at any given moment. They call that information into WSDOT Customer Service staff; often delivering stale information as conditions rapidly change. The Wait Time System will automatically collect, process, and disseminate that information; to terminal operators, Customer Service staff, and the traveling public.

One important component to reviewing the use cases is the difference between travel time and wait time. While third-party traffic data will be an input to the Wait Time System, the concept for this system is focused on wait time, which begins when the traveler enters the queue for the ferry. Travel time is the time it takes, end-to-end, from the start of a user's journey to the boarding of the vessel.

1.4 System Concept

This ConOps provides a description of the system concept from the perspective of the users. The technical specifications regarding vehicle queue and classification data collection, the communications infrastructure necessary to deliver data to a cloud server, and the algorithms developed to integrate and process data will be developed in later stages of the project.

This Executive Summary illustrates one use case; the rest of the use cases are similarly illustrated in the body of the ConOps. ***Figure 2*** describes the experience of the Wait Time System from the perspective of the regular commuter; this is Use Case #1.

The steps Regular Commuter will take in his use of the Wait Time system fall within the following zones:

1.

Planning Zone

The pre-trip part of the traveler's journey where initial decisions can be made about how and when to travel. The Planning Zone generally encompasses the location where the traveler starts their journey, such as home or a workplace. It is in this zone the traveler has the most flexibility in making a decision about how and when to travel. The regular commuter is at the furthest point away from the terminal, and therefore the information is the most subject to change; there is more time between the user and their planned ferry ride than at any other point in the journey.

2.

Decision Zone

The regular commuter has initiated their trip and they are driving to the terminal. On the approach to the terminal, they are armed with the information necessary to make a decision; do they continue with the original plan to take their preferred ferry? Do they park their vehicle and walk aboard? Drive to another terminal, or where possible, skip the ferry altogether and drive to their destination? The Decision Zone is where travelers benefit most from the Wait Time System. With mobile app in hand, the traveler can accurately track the wait time not just at their preferred terminal, but at other nearby locations as well.

3.

Commitment Zone

The traveler has made a decision about how they want to use the ferry system. They are in the vehicle queue, armed with an accurate estimate of how long they might be waiting, and which sailing they can expect to be on. The traveler may reach the toll booth and still decide to make a U-turn, however, that decision is being made in what is considered the Commitment Zone. The user will wait in the queue, and then board the ferry. The user is also contributing their own data to the system for the benefit of other users.

Use Case #1: **Regular Commuters**

The regular commuter drives into Seattle to work several days a week. They are familiar with the region, the traffic patterns from their house to the terminal and from Colman Dock to their office. They know the regular ferry schedule and need only to confirm their plan before they head out to the terminal. They check the WSF travel information mobile application for any notifications about service disruptions or unplanned traffic conditions. If there are any problems on their route, they may choose to leave later, or drive south through the Tacoma area to get to Seattle. If they confirm there are no reported disruptions to the ferry schedule nor city traffic, they maintain their current plan to drive to the terminal, wait in the queue and board their preferred ferry.

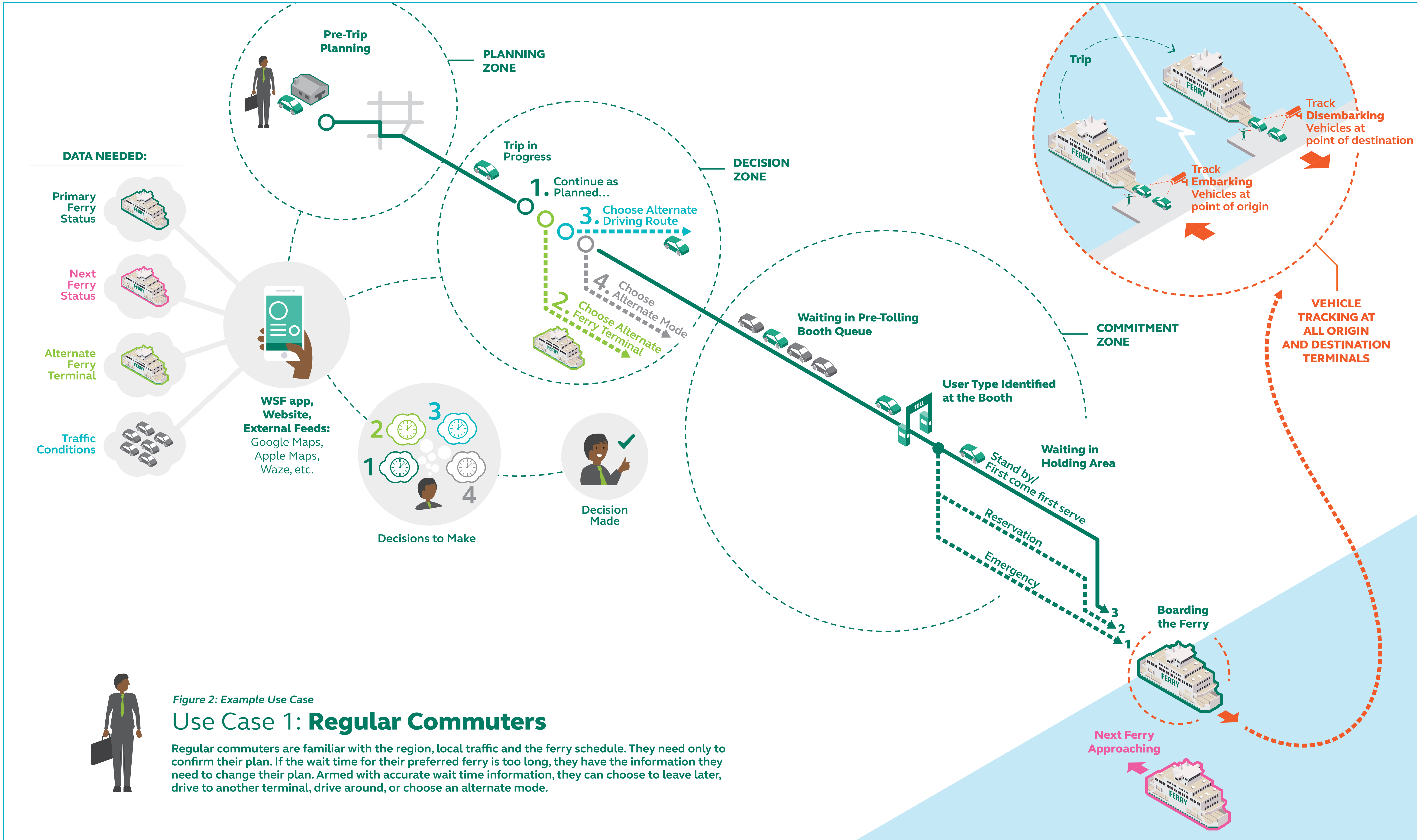


Figure 2: Example Use Case

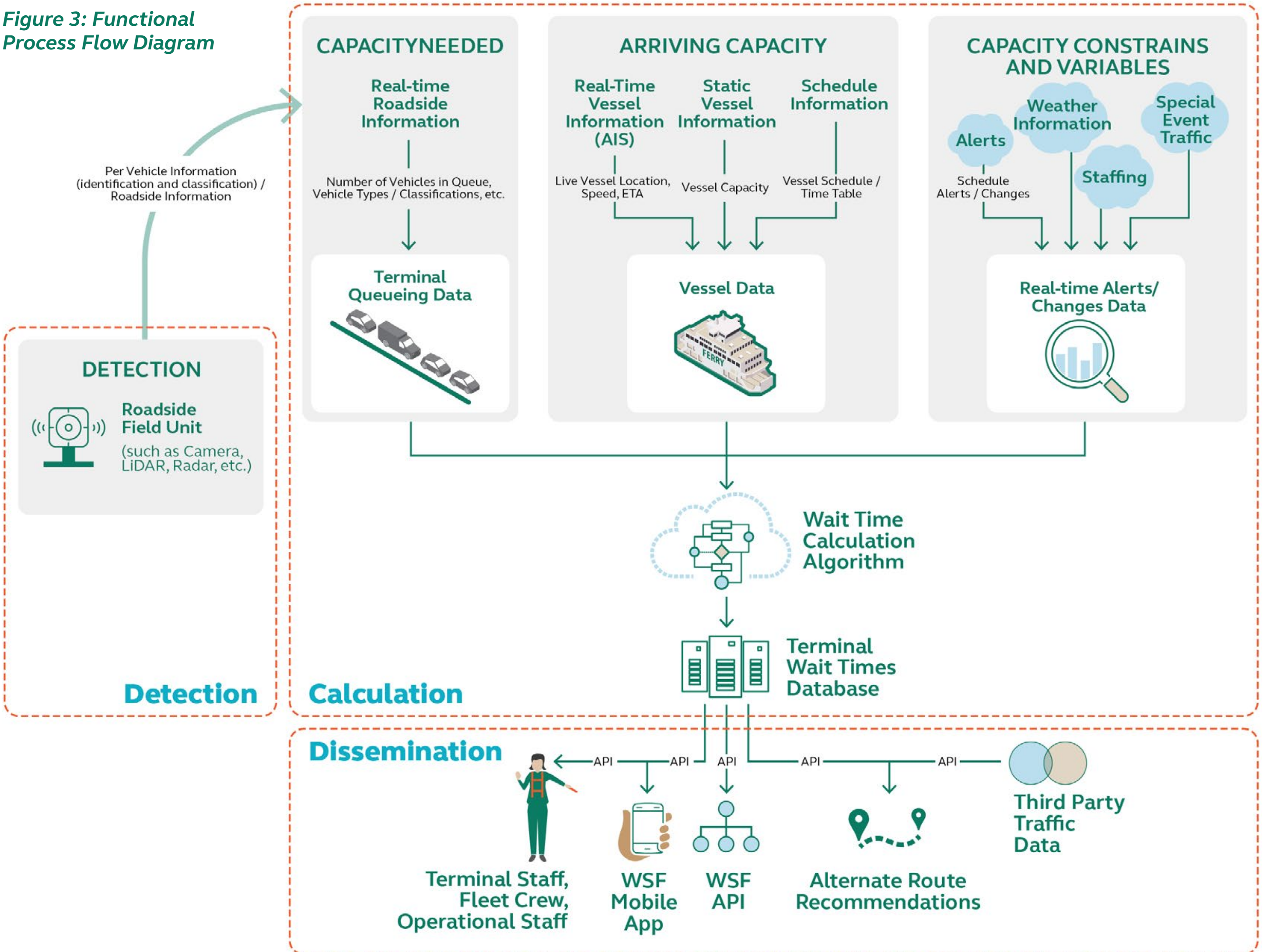
Use Case 1: **Regular Commuters**

Regular commuters are familiar with the region, local traffic and the ferry schedule. They need only to confirm their plan. If the wait time for their preferred ferry is too long, they have the information they need to change their plan. Armed with accurate wait time information, they can choose to leave later, drive to another terminal, drive around, or choose an alternate mode.

1.5 Functional Architecture

The system will reduce the burden on terminal, ferry, and customer information staff to collect and disseminate information by utilizing automated processes where feasible. Automation will be leveraged to detect queues, measure and calculate wait time, and share information. ***Figure 3*** illustrates the system architecture's functional process flow.

Figure 3: Functional Process Flow Diagram



Detection: The system will rely on advanced ITS devices installed in the terminals and along the approaches to detect queuing vehicles, and gather key roadside data on vehicle count, size, and classification, as well as queue length and the rate of queue progression.

Calculation: The system will ingest data from multiple sources to calculate estimated wait times, covering both the local approach and the terminal itself. An algorithm will be developed to process vehicle data from roadside detection devices, vessel data from the Automated Information System (AIS) and the WSF API, along with other supplemental sources. Additionally, the system will integrate third-party traffic data from existing providers to offer alternative routing recommendations for routes with multiple terminal options or drive-around opportunities.

Dissemination: The system will share information with existing mobile applications, WSDOT websites, WSDOT API gateway, and potentially other channels to disseminate information and support real-time decision making.

1.6 Roles and Responsibilities

The impact of the wait time system is expected to be far-reaching, requiring several stakeholder groups to effectively collect information, disseminate wait times and influence traveler decisions to use the ferry system. ***Table 1*** illustrates the wide range of stakeholders who either use, contribute to, or in some way benefit from the Wait Time System.

Table 1: Stakeholders' Roles

Type	Stakeholders	Roles
Administrator	WSDOT	• Responsible for the delivery of the wait time system
Administrator	WSF	• Coordinate with other WSDOT divisions that own and operate approach infrastructure, ITS, cameras, and communications to deploy its system • Integrate existing operational data with the new data collected from the wait time system • Leverage tools produced and managed by WSDOT, including the mobile application and traveler information website • Collaborate on the design and information output to these public channels, following IT policies and regulations for data sharing
Operator	External Relations	• Collaborate on system design • Use Wait Time System data for capital planning efforts, managing vessel availability and ferry scheduling • Use the system as a reliable and consistent source of traveler information • Use the system as a tool for communication with customers regarding ferry service and disruptions
Operator	WSF Terminal Operations	• Collaborate on system design • Use the system as a reliable and consistent source of traveler information within the scope of terminal operations • Use the system to support customer service at terminals
Support	Local Governments	• Collaborate on system design as it relates to local agencies' right of way • Support permitting • Support messaging and marketing to travelers on their right-of-way
Support	Law Enforcement	• Receive alerts regarding vehicles cutting in line
Support	Coast Guard	• Provide vessel data via AIS data stream • Data consumer: as the system evolves, any benefits to COI requirements and processes will be shared and provided for Coast Guard input
Support	Ferry Advisory Committees (FAC)	• Receive information and updates regarding progress of the Wait Time System deployment
Support	Third-party traffic data Providers	• Provide real-time traffic data through API • Consume Wait Time System data through API
User	Travelers	• Primary consumers of Wait Time System output • In future project phases, serve as data providers through location-based services

1.7 Implementation Plan

Wait Time System Implementation Plan

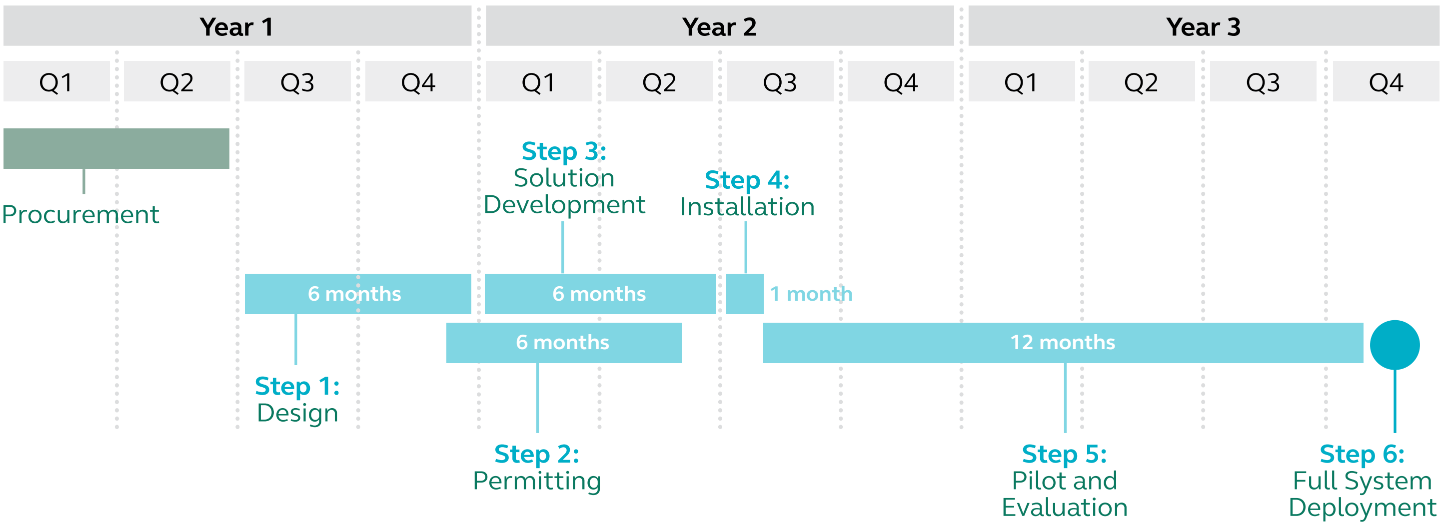


Figure 4: Wait Time System Implementation Plan

Procurement

The procurement process is estimated to take six months. During this time, Washington State Ferries will oversee development of procurement documents, the release of an RFP, evaluation of proposals, and negotiation with the selected team. The procurement concept described recommends a system integrator be responsible for the design, implementation, testing, and deployment of all equipment, systems, software and networks to provide a fully functioning system. A foundational component to the successful implementation will be an interactive design process. The systems integrator will be responsible for demonstrating the system components, and how those components work together to address the functional requirements. The systems integrator will direct and manage the various vendors selected to provide the solution.

Step 1: Design

The implementation process will begin with the design phase. This phase will be interactive with WSF stakeholders, and iterative as initial design concepts are shared, evaluated and improved upon as the process proceeds. The systems integrator will lead the design process. This will include a detailed review of the unique conditions present at many of the terminals.

The systems integrator will develop a System Design Document. The document will identify the components of both the **"Generalized Model"**, the unique elements of the **"Specialized Model"**, and the components of the **"Reservation Model."** The **Generalized Model** will include system functions such as the collection of vehicle queue data, integration with AIS and other data streams, and the dissemination of traveler information. Design elements of the **Specialized Model** will include such considerations, multi-destination data, and the distinguishing of city traffic from ferry terminal traffic. The **Reservation Model** will address the needs and data environment of the reservation terminals. The System Design Document will cover both the field device component as well as the backend software integration and dissemination component. The Design Document will not be finalized until after Step 2.

Timeline: Step 1 is estimated to take 6 months.

Step 2: Permitting and Municipal Coordination

The draft system design will include a list of recommended device and hardware solutions. This ConOps includes the recommendation that the devices supporting AI-enabled cameras using edge computing are the most likely to successfully deliver the functionality required. However, coordination with the cities or municipalities that mange the right of way will be key. Installation of new hardware will need to be properly permitted, and that permitting will require the engagement and buy-in of those partner agencies. The permitting situation will drive the pilot planning; where hardware can be most easily and efficiently permitted will determine where the system is piloted. This step will include the selection of one or more locations to pilot the system.

Timeline: Step 2 is estimated to take 6 months.

Step 3: Solution Development

According to the guidance developed for the System Design Document, the systems integrator will design, develop, test and implement the backend software needed to integrate all Wait Time System and complementary data streams.

Timeline: Step 3 is estimated to take 6 months.

Step 4: Device Installation

The systems integrator will manage and supply all installation activities at the locations selected for the pilot. Installation activities must be characterized by minimal disruption to regular operations of the selected terminals. The System integrator will be responsible for coordinating all installation activities with WSF management and terminal staff.

Timeline: Step 4 is estimated to take 1 month.

Step 5: Pilot and Evaluation

The Wait Time System will be piloted at the Mukilteo Ferry Terminal. Mukilteo is a recommended pilot location because it falls within the 'generalized' model with a single destination route, holding space for waiting vehicles, and options for alternate routing. The pilot will include ongoing evaluation, with input solicited from WSF terminal and Customer Service staff, as well as public surveys.

The pilot will be designed with maximum flexibility, to support expansion during the subsequent phases of system deployment.

Timeline: Step 5 is estimated to take 12 months.

Step 6: Full Deployment

Taking lessons learned from the pilot phase, the system integrator will plan and execute an expansion systemwide, throughout the 20 terminals. The System Design Document developed in Step 1 will help guide the implementation plan and timeline for an effective rollout of the system to a terminals falling under both the 'generalized' and 'specialized' model.

02 Introduction

2.1 Document Purpose

This Concept of Operations (ConOps), developed for Washington State Ferries (WSF) describes the user needs, operational scenarios, and implementation plan for a proposed Ferry Terminal Wait Time Traveler Information System (Wait Time System). This document is a required component of the systems engineering process, which serves as a technical blueprint for effective design, deployment and operation of services based on Intelligent Transportation Systems (ITS).

The purpose of this ConOps is to communicate a clear understanding of user needs and to describe how the system will operate to fulfill those needs. The further purpose of the ConOps is to present a non-technical, easily understandable description of an operational system from the perspective of the users and stakeholders.

The intended audience for this document includes:

- ✓ **WSDOT and WSF managers, planners and executive staff tasked with reviewing and approving the ConOps**
- ✓ **WSF terminal, Customer Service and operational staff, to determine whether their needs have been adequately captured**
- ✓ **A system integrator and system developers who will create and support the Wait Time System based on the user needs and system concepts described in this document**
- ✓ **Other public ferry agencies, to support effective planning to address commonly experienced operational and technical problems**

The ConOps is not meant to serve as a design document for system deployers, and does not include system requirements, technical specifications nor preference for any vendor or consultant.

The major sections of this documents are:

1. **A description of the goals, objectives, and user needs for the proposed system**
2. **The operational concepts that include both the activities of the users and supporting technology**
3. **Sample use cases and operational scenarios**
4. **System functional architecture**
5. **Procurement concept**
4. **Implementation planning support**

The Executive Summary section of this document is meant to serve as an easily understood and shareable high-level description of the system and its major components.

2.2 Background

With the population of the Puget Sound region expected to grow significantly over the next decade, Washington Department of Transportation (WSDOT) has taken steps necessary to better serve ferry customers throughout Puget Sound by planning and deploying a Wait Time Traveler Information System. As the population grows, already serious congestion at the ferries and on the approaches to the terminals is expected to get worse. The impact of Transportation Network Companies (TNC) is already being felt in terminal congestion, and planners need to consider the outcome of new Mobility-as-a-Service (MaaS) providers and users. As with much of our nation's transportation infrastructure, the options to build out of congestion issues, and the funding to support such construction where possible, is limited. The geography and topography of the region precludes opportunities to build additional road, terminal or holding area capacity. Instead, to address the needs of this crucial transportation infrastructure, this ConOps has been developed to support the planning and deployment of an intelligent transportation system.

WSF is seeking to help reduce congestion and level demand, in part by giving travelers more accurate and useful wait times to board the ferries of Puget Sound. Armed with better information, ferry travelers will be able to make informed decisions about how and when to travel; to avoid congestion, decide to walk or bike onto the ferries, take alternate routes, or change their travel plans completely. The focus on providing users with improved information highlights the critical role the Wait Time System will play in the region's broader efforts to reduce congestion and greenhouse gas emissions.

In 2023, WSDOT was awarded a funding opportunity through the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD), a federal program supporting model deployments to reduce congestion and improve transportation-related safety. WSF's proposal was prompted by the various infrastructure and operational needs experienced by WSF and the travelers who use the ferries. The funding was awarded to plan and implement a Ferry Terminal Wait Time System, that will provide automated wait time measurements that supplement existing arterial and highway congestion and incident information. A traveler information system, planned to collect, process, and circulate real-time, actionable traveler information is in alignment with WSF's 2040 Long-Range Plan (LRP), developed in 2019 to provide a regional blueprint to guide the agency's investments in transportation infrastructure over the next two decades. The Long-Range Plan is centered on four major themes, illustrated in ***Figure 5***.

In addition to the specific themes of the LRP, the Traveler Information System is intended to improve the efficiency of terminal operations by serving as a leveler of rapidly growing demand. Knowing the wait time at a specific terminal, and having alternate routes available where possible, can provide travelers with the actionable information they need to decide to travel earlier or later, at less congested times, access a less congested ferry, or opt to drive instead of taking the ferry. A more efficient distribution of demand at ferry terminals is expected to help reduce wait time overall, and support sustainability and resilience of the ferry system overall.

Figure 5: WSF Long Range Plan 2040 Themes

Currently, WSF does not have an automated system that collects vehicle queue nor wait time data. To provide wait times to WSF customer information staff and subsequently the public, terminal staff make estimates based on historical knowledge and expertise, and visual inspection using both closed-circuit television camera (CCTV) images and physical inspection of the approaches to the terminals.

With the deployment of the Wait Time System, real-time, actionable information will supplement existing local and regional channels of traveler information, to ultimately provide expanded situational awareness and provide more comprehensive travel information to local, regional, and through-travelers. The system will integrate several data streams from WSDOT, the Coast Guard and third-party traffic data providers such as Google and Waze. That integrated data will allow ferry customers to make more informed travel decisions.

Traveler information data can be used for multiple purposes, and the data collected by the Wait Time System will benefit operations staff as well as travelers. The current lack of an information system regarding wait times impacts not only the travelers who use the ferry system, but system operators and regional transportation planners. Accurate, real-time data will allow operational staff to make more informed and more efficient service decisions, especially when a vessel is taken out of service due to unscheduled maintenance, the impact of inclement weather, low tide warnings or other reasons. Long-term planning will also benefit from more accurate and reliable wait time information, as a better understanding of wait and disruption impacts can make the case for additional or modified service or other mechanisms to manage demand on the ferry system. Accurate information about travelers queued up at the terminals will support operational goals of moving travelers and commerce more effectively across the region.

2.3 Referenced Documents

The following documents were reviewed and assessed to distill key user needs and system functionalities:

- ACTMTD Proposal
- ACTMTD Data Management Plan
- ACTMTD Evaluation Plan initial FHWA feedback
- Washington State Ferries Terminal Wait Time Performance Evaluation Plan
- Washington State Ferries Travel Wait Time Kick-off Meeting
- Travel Wait Times Project Charter
- Washington State Ferries 2024 Long Range Plan
- FY 2023 Washington Department of Transportation Ferries Division Performance Report
- Passenger Demographic Survey Report
- WSF website traveler information sources
- WSDOT mobile App
- WSF Sustainability Action Plan: 2023-2025
- Concept Exploration and Recommendations Report / Cascade Gateway Advanced Border Information System Design Project
- National Institute of Standards and Technology (NIST)
- Cybersecurity & Infrastructure Security Agency (CISA)

03 Wait Time System Overview

3.1 Project Concept Summary

This ConOps describes a ferry terminal wait time traveler information system that will automatically collect vehicle queue and classification data, measure the progress of the vehicles, deliver data to a central cloud server or virtual machine, integrate with relevant parallel data streams, employ an algorithm to calculate estimated wait times, and disseminate information to the traveling public.

The workflow is illustrated at a high level in ***Figure 6.***

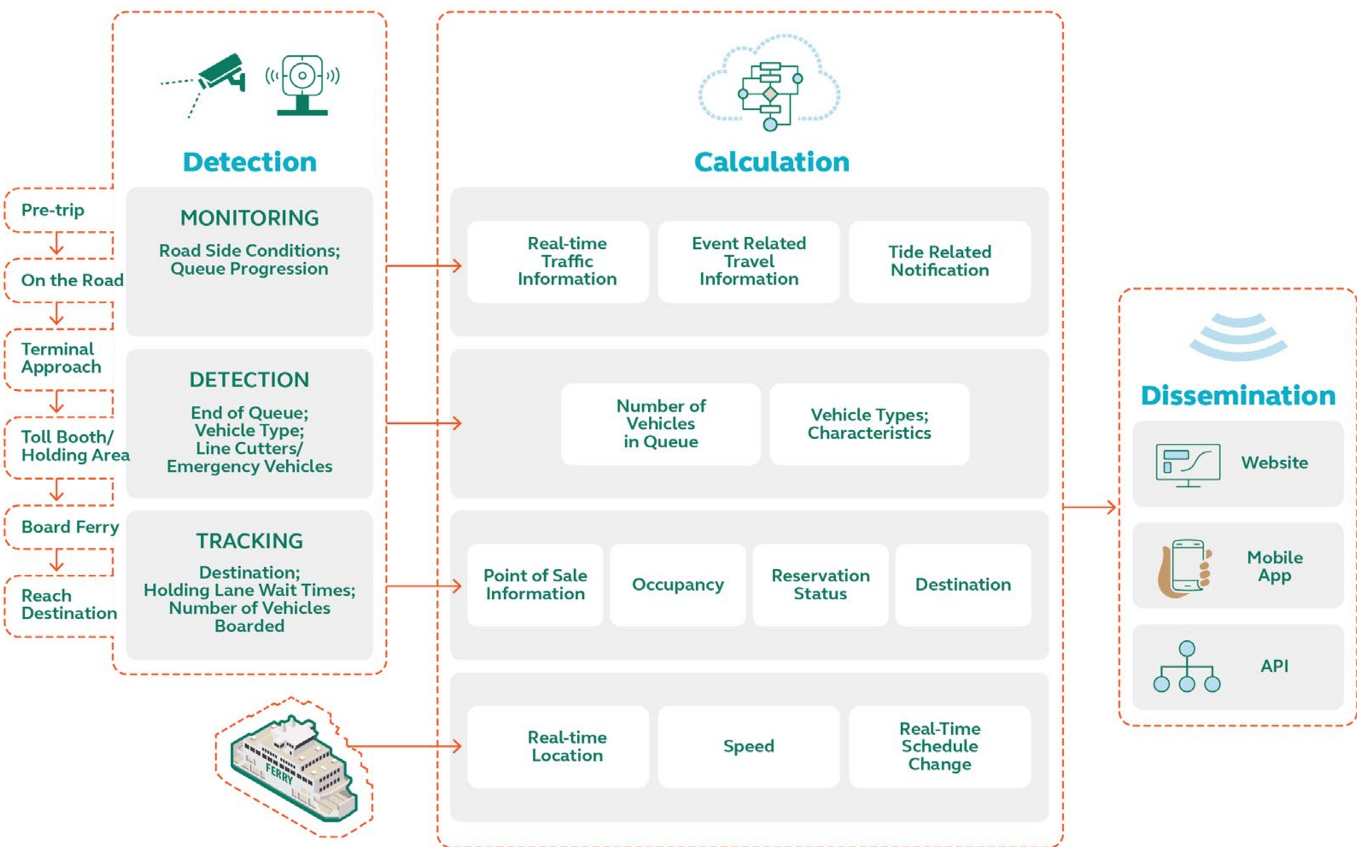


Figure 6: Functional Process Flow

Detection: The system will rely on advanced ITS devices installed in the terminals and along the immediate approach to detect queuing vehicles, and gather key roadside data on vehicle count, size, and classification, as well as queue length and the rate of queue progression. The type of hardware suggested in the Implementation Plan in Section 5 is AI-enabled cameras, in concert with video analytics on the backend. Radar may also be used to collect data at some terminals. Wait time will be advisory or estimated and reflect the wait time for the preceding period (e.g. last 15-min). Historical data will be used to predict future congestion and wait time.

The system will reduce the burden on terminal, ferry, and customer information staff to collect and disseminate information by utilizing automated processes where feasible. Automation will be leveraged to detect queues, measure and calculate wait time, and share information.

Calculation: The system will ingest data from multiple sources to calculate estimated wait times, covering both the local approach and the terminal itself. An algorithm will be developed to process vehicle data from roadside detection devices, vessel data from the Automated Information System (AIS) data and the WSDOT API gateway, along with other supplemental sources. Additionally, the system will integrate third-party traffic data from existing providers to offer alternative routing recommendations for routes with multiple terminal options or drive-around opportunities. APIs from third-party traveler information services will also be integrated into the algorithm.

Dissemination: The system will share information with existing mobile applications, WSDOT websites, the WSDOT API gateway and potentially other channels to disseminate information and support real-time decision making. The system will leverage the WSDOT traveler information mobile app and website as a primary traveler information tool to disseminate wait time information and merge with other relevant trip-planning features. Data calculated by the system will also be available back to those third-party traffic data providers, as well as independent developers who request a developer's key.

The 20 terminals that comprise WSF's ferry system present a complex environment in which to develop an effective, consistent system. Throughout the terminals of the Puget Sound, some include reservations, some do not. Some terminals include adequate holding capacity for waiting vehicles; some require vehicles to queue out into city streets, competing for space with local residents and travelers. Some terminals are true islands, with no access except for ferries; some can be avoided by driving instead of boarding. This ConOps presents a concept for system deployment throughout the entire ferry system, including those that are characterized by unique or outlier conditions. The variability of those geographical, topographical and operational differences is addressed by developing three modalities:

- **Generalized Model** - The generalized model includes the basic functionalities, parameters, and calculations relevant to most terminals. The generalized system is equipped to support terminals that do not accept reservations, terminals with alternative routes, and terminals that service only one destination.
- **Specialized Model** - The specialized model will be developed to support terminals with unique characteristics that are not captured within the generalized system functionality. These parameters include terminals that accept reservations, terminals with no alternative route options, terminals with multiple destinations serviced, and locations that include unique physical challenges such as train tracks that can interfere with queuing vehicles.
- **Reservations Model** - Terminals that accept reservations, seasonal and year-round, are counted in this category.

A listing of the terminals by model is presented in ***Table 2.***

Table 2: Terminals by Model

Terminal	Generalized Model	Specialized Model	Reservation Model
Anacortes			●
Bainbridge Island	●		
Bremerton	●		
Clinton	●		
Coupeville			●
Edmonds		●	
Fauntleroy		●	
Friday Harbour			●
Kingston	●		
Lopez Island			●
Mukilteo	●		
Orcas Island			●
Point Defiance	●		
Port Townsend			●
Seattle		●	
Shaw Island			●
Sidney B.C.			●
Southworth		●	
Tahlequah	●		
Vashon Island		●	

3.2 Intended Audience

The ConOps is intended for stakeholders who are expected to have a role in the development, design, implementation, operation or support of the ferry wait time system. These stakeholders include:

1. WSDOT and WSF managers, planners and executive staff tasked with reviewing and approving the ConOps
2. WSF terminal, Customer Service and operational staff to determine whether their needs have been adequately captured
3. A system integrator and system developers who will create and support the Wait Time System based on the user needs and system concepts described in this document
4. Other public ferry agencies, to support effective planning to address commonly experienced operational and technical problems

The ConOps was developed with review, comment, and input by key WSF staff to inform the primary goals, vision, and functionality. Additionally, the ConOps considered input received from several ferry agencies dealing with relevant operational challenges. As such, this ConOps is also intended to be a tool for other state and local agencies looking to deploy a similar wait time system in other regions. Lessons for system development and key considerations will be captured and disseminated to relevant to agencies.

3.3 Vision, Goals, and Objectives

3.3.1 Vision

The ConOps is guided by a central vision. This vision serves as an overarching theme of this document, as well as the system eventually designed and deployed. Every step along the path to system deployment; collection of user needs and challenges, development of the concept that guides the system, to design, deployment and operation of the system will have this vision at its core:

> ***"Ferry travelers will be able to access real-time wait time information, accurate and timely enough to make decisions in advance, and in the moment about how and when to travel. Accurate information supported by historical data and predictive modeling, will allow drivers to consider other options such as switching to other modes of travel, using active transportation rather than driving, traveling during less congested times, driving to a less congested ferry, or driving to their destination rather than take the ferry at all. Data collected by the Wait Time System will give WSF planners and managers information to support efficient planning and investment."***

3.3.2 Goals

The goals for the Wait Time System were developed to guide system development and set a guidepost for which the system can be measured against to assess performance in future. The goals for this project were gathered from supporting documentation and stakeholder input received during the development of this ConOps. The ConOps defines the goals of the system as follows:

- **Advance the goals of the 2040 Long Range Plan –** The ACTMTD grant proposal developed by WSDOT was largely supported by the region's 2040 Long Range Plan The goals of the Long Range plan; service reliability, customer experience ridership growth and system sustainability. Those goals are mentioned in Section 1.2, page 2.

- **Relieve congestion across the transportation network –** Access to actionable wait times across the ferry system will help level demand; travelers will have the information they need to arrive at a congested terminal later, or avoid a busy terminal altogether. The system will also relieve congestion in the neighborhoods surrounding terminals.
- **Improve efficiency at the terminals for staff –** Staff currently tasked with manually assessing queuing vehicles and estimating wait time will be able to rely on an automated system to do so. Reduced congestion due to a leveling of demand system-wide will contribute to an improved experience for travelers.
- **Contribute to greenhouse gas reduction goals –** WSF expects to create environmental benefits associated with improvement queue detection and communication capabilities at terminals. A reduction in congestion at terminals, or a switch to travel on more efficient routes, enabled by improved traveler information, will support a parallel reduction in the greenhouse gases created by idling vehicles. In particular, WSF hopes to reduce the number of vehicles who arrive early and idle in line for longer periods.
- **Improve the customer experience –** The travelers on WSF's ferry system currently have little access to accurate, real-time, decision-quality traveler information. A driver armed with information can make better choices about how and when to travel; avoiding congestion or delays caused by service disruption, deciding if it makes sense to drive to another terminal or even skip the ferry altogether. Even when there is little choice, that traveler still benefits from having the available information in hand.

3.3.3 Objectives

While goals are aspirational ideas to help guide the project, objectives tell what actions must be taken or achieved to address those goals. The following objectives provide measurable actions in the short term to achieve the system's vision and address the goals. The goals established for the Wait Time System will be supported by objectives focused in three areas:

- Data Collection
- Data Processing / Integration
- Data Dissemination / Traveler Information

The objectives for the Wait Time System are outlined below:

Leverage Existing ITS and Tools – While new devices and sensors will be necessary to capture new data, the system will wherever possible leverage existing ITS infrastructure such as IP-based cameras operational at the terminals and on the approaches, the existing WSF API and WSDOT mobile applications.

Relieve Staff of Manual Estimations and Postings – The Wait Time System will rely on automated systems to detect and calculate a wait time. The system will be monitored by the system integrator and relieve WSF customer service and terminal operations staff of time spent estimating wait and posting wait time updates. The system will regularly refresh providing near-real time estimates for the traveling public.

Automatically collect vehicle data – With the deployment of advanced devices and sensors within and surrounding the terminals, the system will collect vehicle queue and classification data. The Wait Time System will also detect vehicles that cut into the established line and be able to follow a vehicle as it proceeds through the process until boarding. To support requirements focused on multi-destination routes, data will be collected from the moment a vehicle gets into the queue, to the time he gets off the ferry at his designation.

Query and Integrate Existing and New Data – The Wait Time System will be supported by a sophisticated algorithm (or set of algorithms working in concert) that integrate disparate data and process that data to estimate a wait time and recommend alternative travel routing. Data sources that will be utilized include: AIS vessel data; WSF API data; queue length; queue travel time; third-party traffic data.

Distribute Demand and Enable Mode Shift with Alternative Routing – The Wait Time System will also integrate with third-party traffic data to generate alternative routing suggestions which will enable the travelling public to make informed decisions. This includes recommending alternative routes to relieve congestion on the ferry system or highway network, while also recommending fastest routes including walk-on options which will encourage mode shift.

Disseminate Data for Decision Making – The Wait Time System algorithms will work to properly integrate multiple data streams and produce actionable, accurate, and reliable information for decision-making and use by the following key users and operators:

- **End-Users:**
  - > Traveling Public users will utilize wait time as it pertains to traveler information and travel time estimates accessed through various mobile applications. The information will be made available via several platforms (include WSDOT mobile app) with an emphasis on integrating with other traveler information data. Information and alerts will be disseminated via VMS and alert subscribers where available.
  - > Third party data and service providers will utilize wait time data made available through the API. Registered developers and third-party traffic providers such as Google, Apple, Tom Tom and others can then integrate with traffic data.
- **WSF Staff**
  - > Terminal staff will use the data for accurate situational awareness, and will no longer have to report estimated wait times to Customer Service staff. WSF Customer Service staff will operate the system and utilize its output to plan for service, and use it as a tool for communications with customers.

3.4 Roles and Responsibilities

The impact of the wait time system is expected to be far-reaching, requiring several stakeholder groups to effectively collect information, disseminate wait times and influence traveler decisions to use the ferry system. The stakeholders identified in ***Table 3*** are proposed as they support four key stakeholder types:

- **Administrator –** the entity responsible for system development and delivery
- **Operator –** the entity responsible for day-to-day management and monitoring of the system
- **Support –** entities who are consulted and informed of system performance and changes. These entities may provide data or input to the system and may be impacted on their right-of-way. These entities are not responsible
- **Users –** entities that utilize the system but do not provide direct input into how the system functions or is delivered

Table 3: Stakeholder Roles & Responsibilities

Type	Stakeholders	Roles
Administrator	WSDOT	• Responsible for the delivery of the wait time system
Administrator	WSF	• Coordinate with other WSDOT divisions that own and operate approach infrastructure, ITS, cameras, and communications to deploy its system • Integrate existing operational data with the new data collected from the wait time system • Leverage tools produced and managed by WSDOT, including the mobile application and traveler information website • Collaborate on the design and information output to these public channels, following IT policies and regulations for data sharing
Operator	External Relations	• Collaborate on system design • Use Wait Time System data for capital planning efforts, managing vessel availability and ferry scheduling • Use the system as a reliable and consistent source of traveler information • Use the system as a tool for communication with customers regarding ferry service and disruptions
Operator	WSF Terminal Operations	• Collaborate on system design • Use the system as a reliable and consistent source of traveler information within the scope of terminal operations • Use the system to support customer service at terminals • Use system to forecast staffing needs
Support	Local Governments	• Collaborate on system design as it relates to local agencies' right of way • Support permitting • Support messaging and marketing to travelers on their right-of-way
Support	Law Enforcement	• Receive alerts regarding vehicles cutting in line
Support	Coast Guard	• Provide vessel data via AIS data stream • Data consumer: as the system evolves, any benefits to COI requirements and processes will be shared and provided for Coast Guard input
Support	Ferry Advisory Committees (FAC)	• Receive information and updates regarding progress of the Wait Time System deployment
Support	Third-party traffic data Providers	• Provide real-time traffic data through API • Consume Wait Time System data through API
User	Ferry Travelers	• Primary consumers of Wait Time System output • In future project phases, serve as data providers through location-based services

3.5 Use Cases and Operational Scenarios

Previous sections have outlined the system concept; how it is intended to function and be developed, and the key stakeholders and users. It is critical that the outputs of the ConOps keep the user in mind and provide information relevant to the perspective of the system users. A ConOps envisions an operational system first and foremost from the perspective of the users, focused not on how the system is architected on the backend, but how it works, in whatever interface is preferred, for those who will eventually benefit from its deployment.

Use cases in this ConOps rely on the concept of three zones to describe the decision phases a traveler goes through as a ferry customer: Planning Zone, Decision Zone, Commitment Zone. These zones differ in size or duration, depending on the use case, and are used as a framework to illustrate the use cases in this section. A brief description of each zone is:

1.

Planning Zone

The pre-trip part of the traveler's journey where initial decisions can be made about how and when to travel. The Planning Zone generally encompasses the location where the traveler starts their journey, such as home or a workplace. It is in this zone the traveler has the most flexibility in making a decision about how and when to travel. The regular commuter is at the furthest point away from the terminal, and therefore the information is the most subject to change; there is more time between the user and their planned ferry ride than at any other point in the journey.

2.

Decision Zone

The regular commuter has initiated their trip and they are driving to the terminal. On the approach to the terminal, they are armed with the information necessary to make a decision; do they continue with the original plan to take their preferred ferry? Do they park their vehicle and walk aboard? Drive to another terminal, or where possible, skip the ferry altogether and drive to their destination? The Decision Zone is where travelers benefit most from the Wait Time System. With mobile app in hand, the traveler can accurately track the wait time not just at their preferred terminal, but at other nearby locations as well.

3.

Commitment Zone

The traveler has made a decision about how they want to use the ferry system. They are in the vehicle queue, armed with an accurate estimate of how long they might be waiting, and which sailing they can expect to be on. The traveler may reach the toll booth and still decide to make a U-turn, however, that decision is being made in what is considered the Commitment Zone. The user will wait in the queue, and then board the ferry. The user is also contributing their own data to the system for the benefit of other users.

This section provides several examples of potential users of the system, using a simple diagram to describe their experience. Five use cases are presented in ***Figures 7, 8, 9, 10, and 11.***

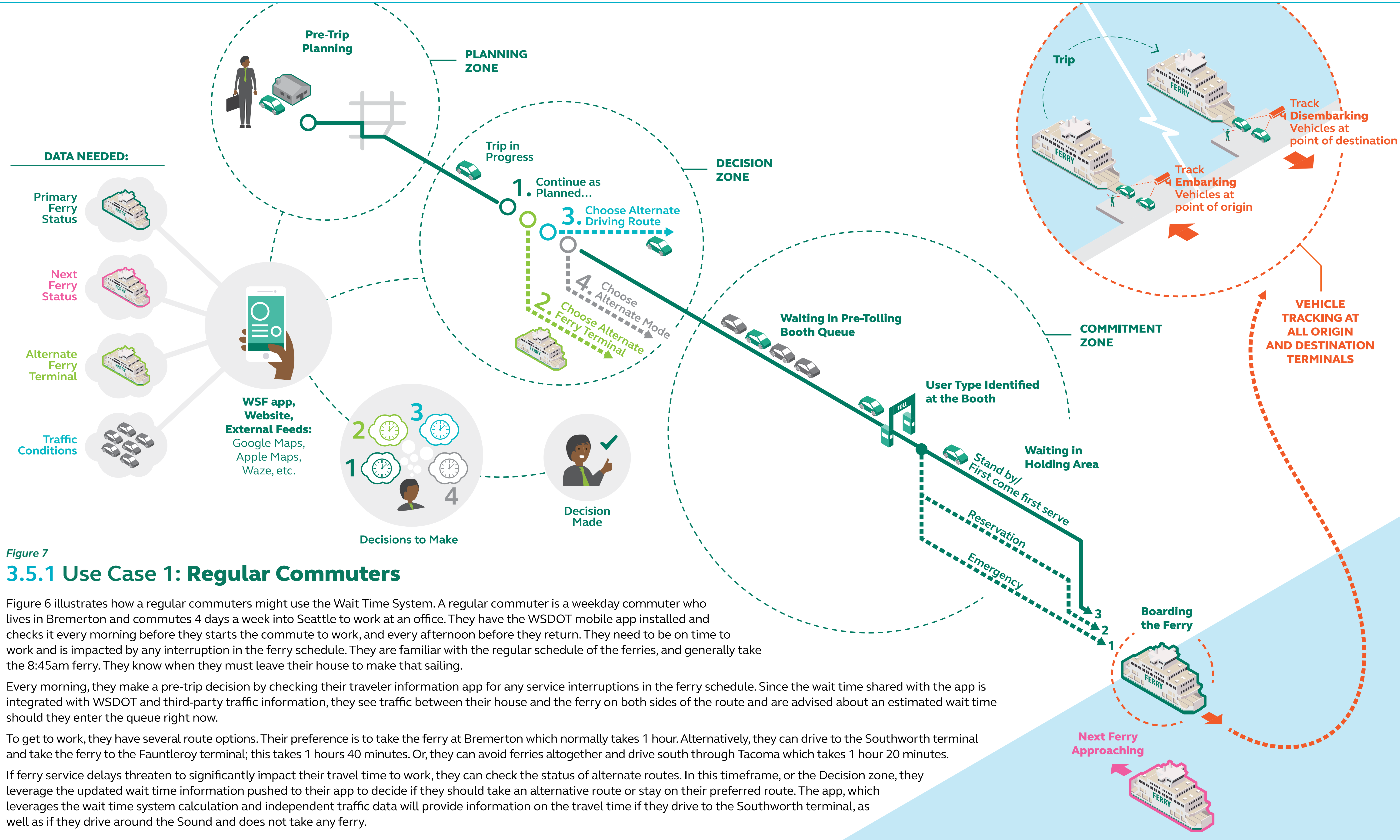


Figure 7

3.5.1 Use Case 1: **Regular Commuters**

Figure 6 illustrates how a regular commuters might use the Wait Time System. A regular commuter is a weekday commuter who lives in Bremerton and commutes 4 days a week into Seattle to work at an office. They have the WSDOT mobile app installed and checks it every morning before they starts the commute to work, and every afternoon before they return. They need to be on time to work and is impacted by any interruption in the ferry schedule. They are familiar with the regular schedule of the ferries, and generally take the 8:45am ferry. They know when they must leave their house to make that sailing.

Every morning, they make a pre-trip decision by checking their traveler information app for any service interruptions in the ferry schedule. Since the wait time shared with the app is integrated with WSDOT and third-party traffic information, they see traffic between their house and the ferry on both sides of the route and are advised about an estimated wait time should they enter the queue right now.

To get to work, they have several route options. Their preference is to take the ferry at Bremerton which normally takes 1 hour. Alternatively, they can drive to the Southworth terminal and take the ferry to the Fauntleroy terminal; this takes 1 hours 40 minutes. Or, they can avoid ferries altogether and drive south through Tacoma which takes 1 hour 20 minutes.

If ferry service delays threaten to significantly impact their travel time to work, they can check the status of alternate routes. In this timeframe, or the Decision zone, they leverage the updated wait time information pushed to their app to decide if they should take an alternative route or stay on their preferred route. The app, which leverages the wait time system calculation and independent traffic data will provide information on the travel time if they drive to the Southworth terminal, as well as if they drive around the Sound and does not take any ferry.

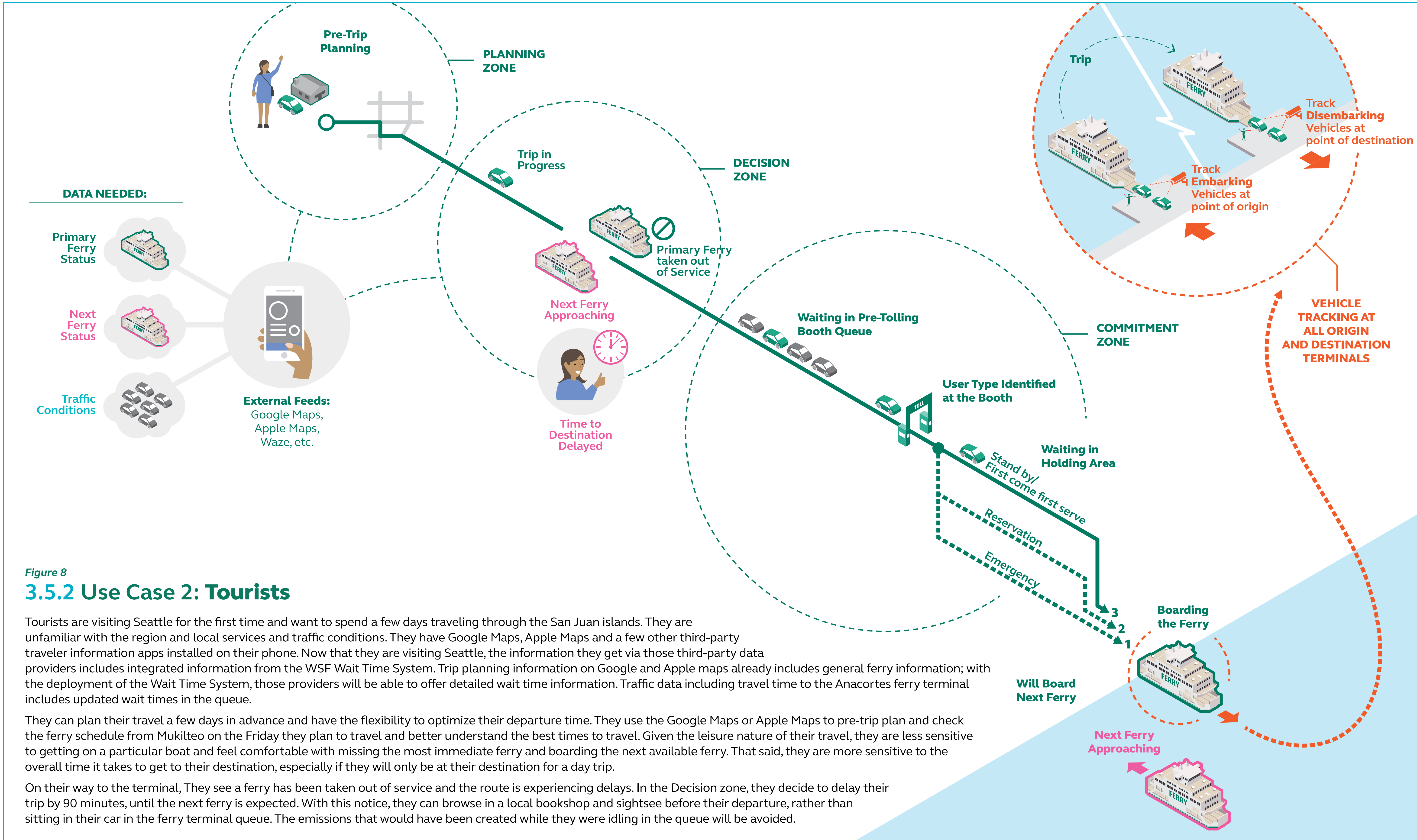


Figure 8

3.5.2 Use Case 2: **Tourists**

Tourists are visiting Seattle for the first time and want to spend a few days traveling through the San Juan islands. They are unfamiliar with the region and local services and traffic conditions. They have Google Maps, Apple Maps and a few other third-party traveler information apps installed on their phone. Now that they are visiting Seattle, the information they get via those third-party data providers includes integrated information from the WSF Wait Time System. Trip planning information on Google and Apple maps already includes general ferry information; with the deployment of the Wait Time System, those providers will be able to offer detailed wait time information. Traffic data including travel time to the Anacortes ferry terminal includes updated wait times in the queue.

They can plan their travel a few days in advance and have the flexibility to optimize their departure time. They use the Google Maps or Apple Maps to pre-trip plan and check the ferry schedule from Mukilteo on the Friday they plan to travel and better understand the best times to travel. Given the leisure nature of their travel, they are less sensitive to getting on a particular boat and feel comfortable with missing the most immediate ferry and boarding the next available ferry. That said, they are more sensitive to the overall time it takes to get to their destination, especially if they will only be at their destination for a day trip.

On their way to the terminal, They see a ferry has been taken out of service and the route is experiencing delays. In the Decision zone, they decide to delay their trip by 90 minutes, until the next ferry is expected. With this notice, they can browse in a local bookshop and sightsee before their departure, rather than sitting in their car in the ferry terminal queue. The emissions that would have been created while they were idling in the queue will be avoided.

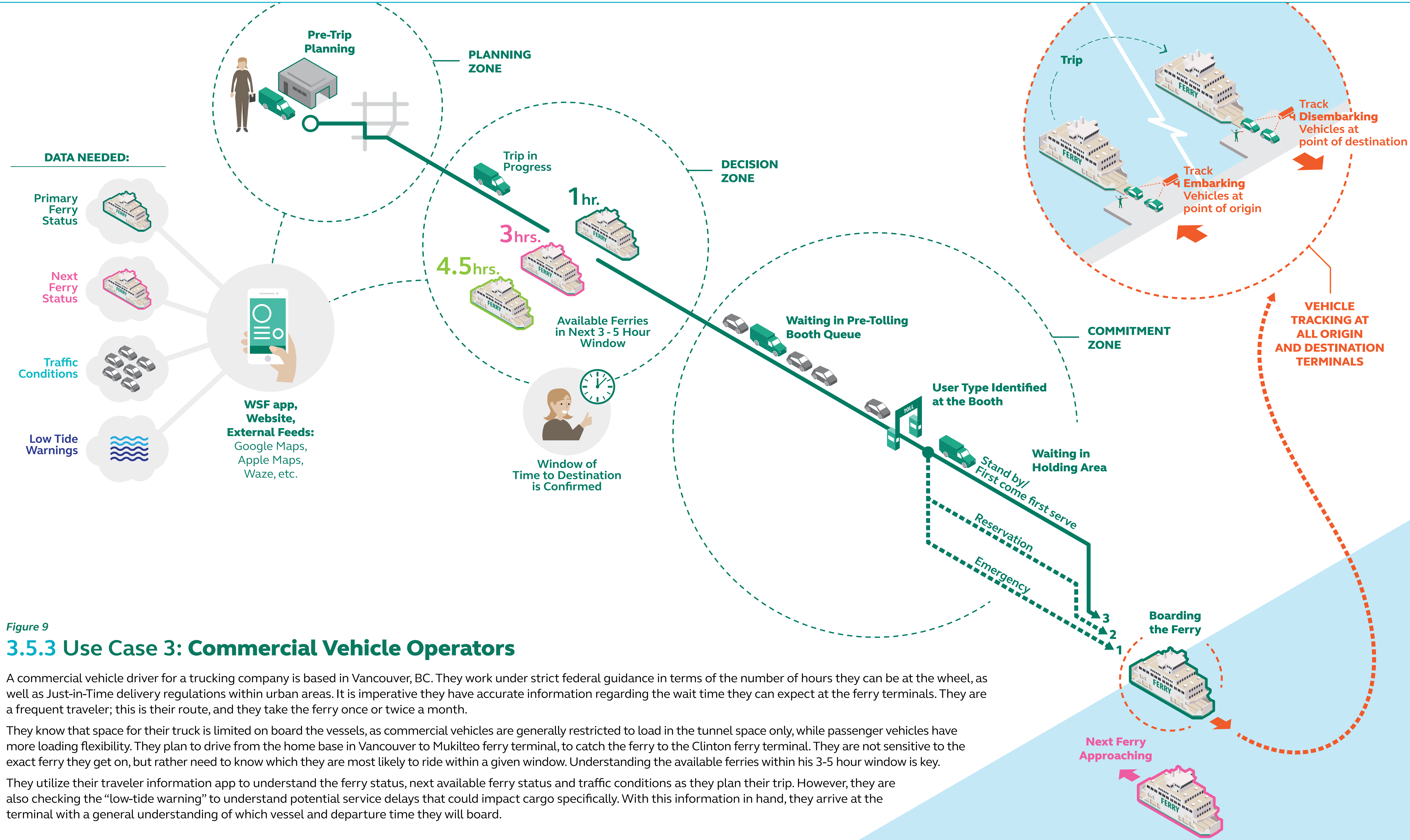


Figure 9

3.5.3 Use Case 3: **Commercial Vehicle Operators**

A commercial vehicle driver for a trucking company is based in Vancouver, BC. They work under strict federal guidance in terms of the number of hours they can be at the wheel, as well as Just-in-Time delivery regulations within urban areas. It is imperative they have accurate information regarding the wait time they can expect at the ferry terminals. They are a frequent traveler; this is their route, and they take the ferry once or twice a month.

They know that space for their truck is limited on board the vessels, as commercial vehicles are generally restricted to load in the tunnel space only, while passenger vehicles have more loading flexibility. They plan to drive from the home base in Vancouver to Mukilteo ferry terminal, to catch the ferry to the Clinton ferry terminal. They are not sensitive to the exact ferry they get on, but rather need to know which they are most likely to ride within a given window. Understanding the available ferries within his 3-5 hour window is key.

They utilize their traveler information app to understand the ferry status, next available ferry status and traffic conditions as they plan their trip. However, they are also checking the "low-tide warning" to understand potential service delays that could impact cargo specifically. With this information in hand, they arrive at the terminal with a general understanding of which vessel and departure time they will board.

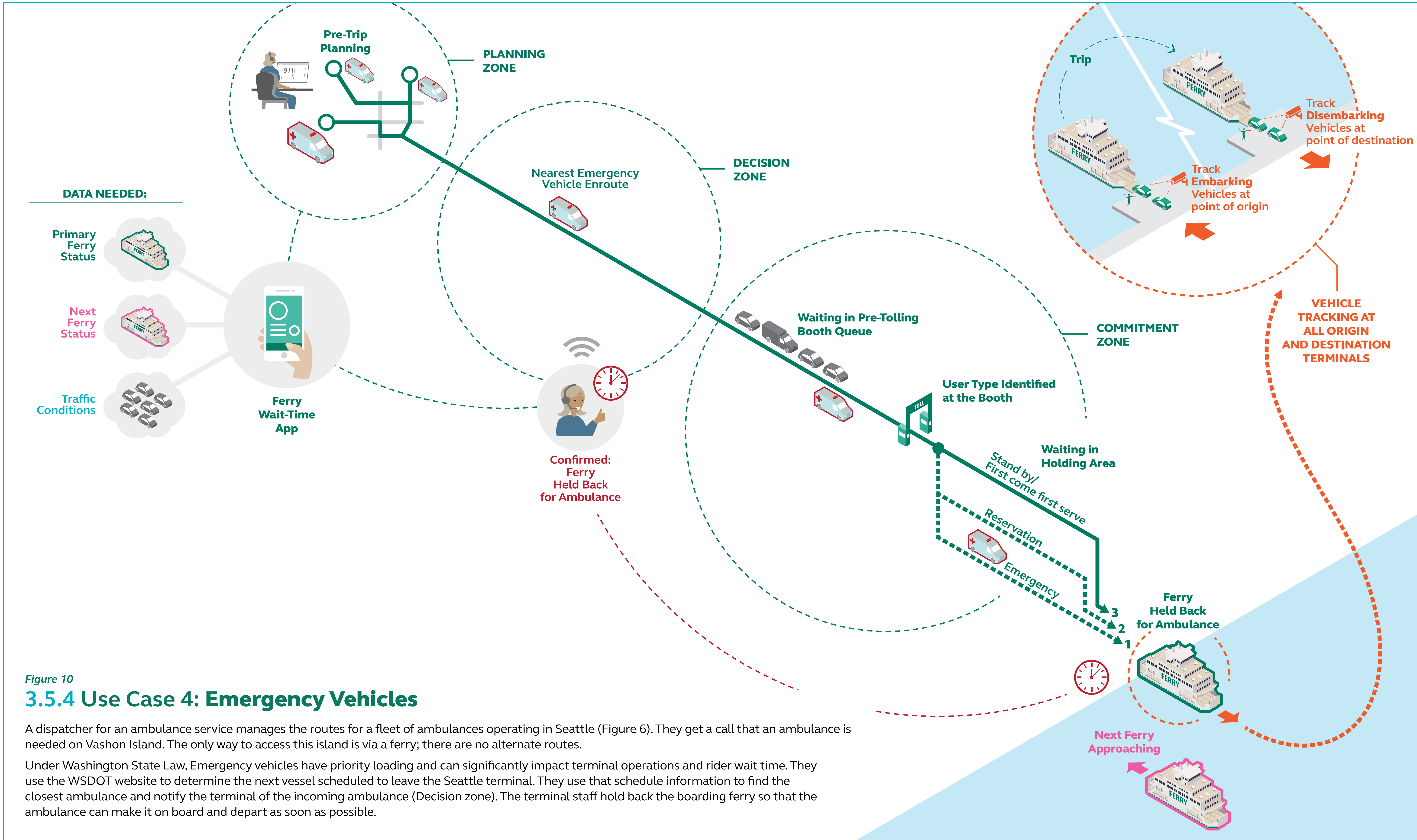
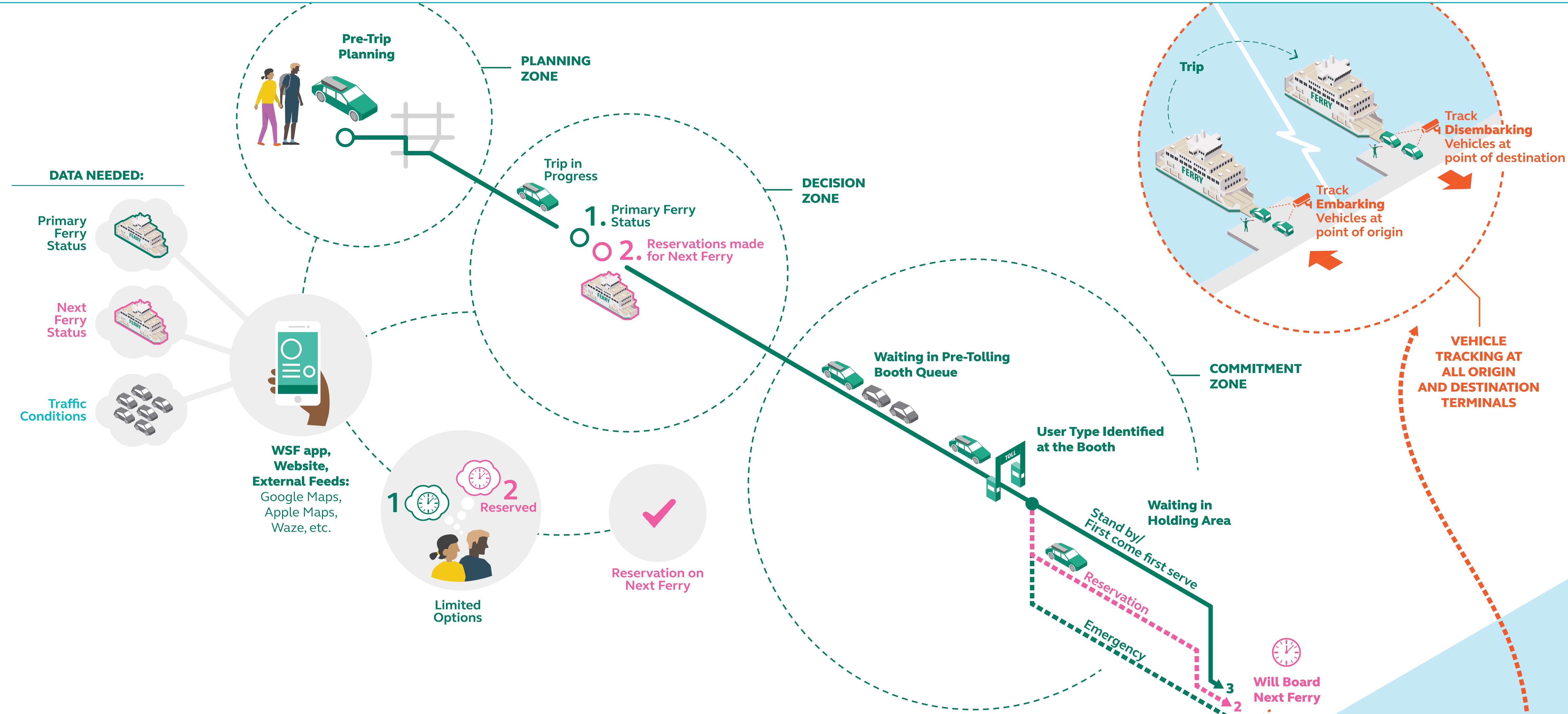


Figure 10

3.5.4 Use Case 4: **Emergency Vehicles**

A dispatcher for an ambulance service manages the routes for a fleet of ambulances operating in Seattle (Figure 6). They get a call that an ambulance is needed on Vashon Island. The only way to access this island is via a ferry; there are no alternate routes.

Under Washington State Law, Emergency vehicles have priority loading and can significantly impact terminal operations and rider wait time. They use the WSDOT website to determine the next vessel scheduled to leave the Seattle terminal. They use that schedule information to find the closest ambulance and notify the terminal of the incoming ambulance (Decision zone). The terminal staff hold back the boarding ferry so that the ambulance can make it on board and depart as soon as possible.



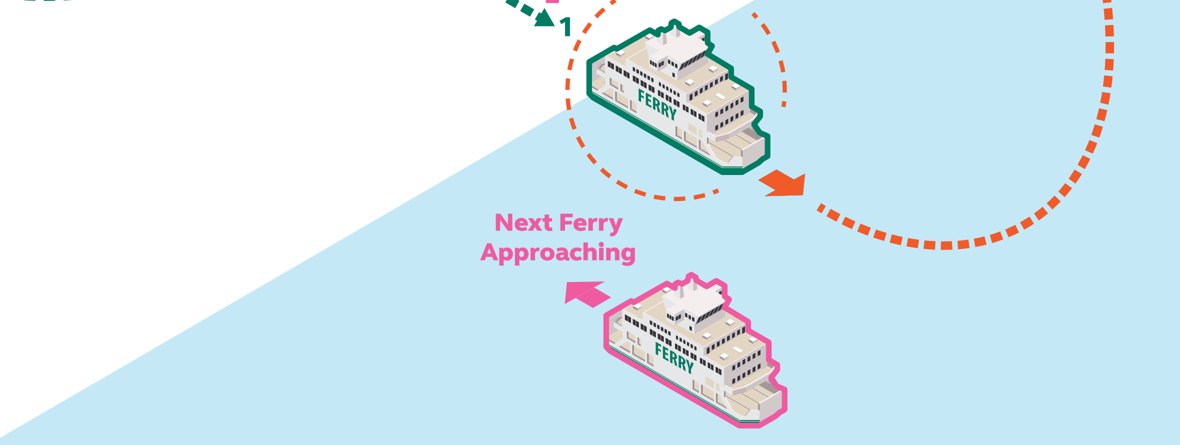
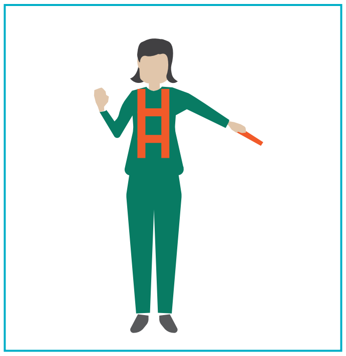


Figure 11

3.5.5 Use Case 5: **Recreational Users**

Rexcreational users live and work in Seattle and own a cabin on Orcas Island. The ferry is the only mode of transportation to reach the Island as there is no driving alternative.

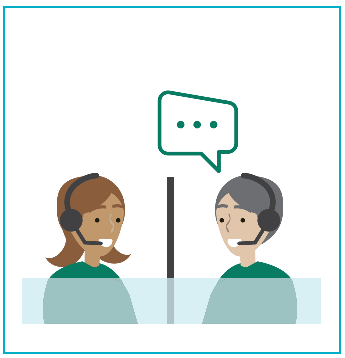
They take the ferry from Anacortes, which has a reservation system; they always use reservations to plan their weekend trips to the cabin. While they are familiar with the trip and available options, they downloaded the mobile app the last time they took the ferry from Seattle, as they saw marketing material at the terminal advertising the new app. They began using the app to check the ferry schedule from Anacortes on the Friday they plan to travel. This helps them determine if the ferry will be on-time or delayed. They see a ferry they previously reserved has been taken out of service, so they choose to delay their trip by 90 minutes, until the next ferry is expected. With the information they need in hand, they can wait in the comfort of their home rather than sitting in their car, in the ferry terminal queue.



3.5.6 Use Case 6: Terminal Staff

Wait Time System will produce data valuable to WSF staff as well as the traveling public. Before the wait time system was deployed, terminal staff used manual methods to calculate wait time; they had to make estimates based on terminal camera images, or physically look at the queuing vehicles. Terminal staff provide on-site reporting to the off-site customer service teams regarding estimated wait time, estimated ferry arrival time, and any active events or disruptions that are expected to or are impacting operations. The Wait Time system takes those manual tasks out of the scope of terminal staff operations, instead sending the data automatically to the central server.

With the wait time system in place, Terminal staff instead can check the WSDOT app for the wait times they used to have to assess manually. Wait time data now collected and disseminated automatically is more accurate and takes no input from terminal staff, thereby shifting the burden of queue detection and estimation to technology. The technologies will dynamically assess the shifting queue and update without human intervention. This allows terminal staff to prioritize vessel loading and unloading, vehicle staging and ticketing on the ferry dock.



3.5.7 Use Case 7: WSF Customer Service Staff

WSF Customer Service staff includes a call center comprised of phone agents who respond to customer questions and feedback and take reservations, and web agents who monitor/manage website applications, respond to written customer inquiries, and post/send unique, customer, travel alerts. The Wait Time System will provide data automatically to customer service staff, mitigating the need for customer service staff to confirm conditions with terminal staff on-site, and eliminating the need to provide the information manually to WSF's traveler information channels. By automating the data collection, processing and dissemination of wait time information, the proposed system will remove those tasks from customer service staff's scope. Additionally, the wait time system can be a resource Customer Service staff can share with the public for updated information on the wait time conditions at the terminals, one that is updated at a regular cadence rather than the current ad-hoc method.

3.5.8 Use Case 8: WSF Planners / Managers

The Wait Time System will allow WSF planners, managers and other decision-makers to use accurate data for future planning. With the significant growth of the region expected over the next decade, paired with aging vessels and terminals that cannot be expanded due to space limitations, data is needed to make informed, intelligent decisions guiding investment and operational changes. Historical wait time data, terminal-by-terminal, will supplement the usage and capacity data currently available to planners. The influx of accurate usage and demand data will help guide, and lend justification for WSF's future planning.

04

Technical Components

4.1 High-level System Architecture

A high-level system architecture for the Wait Time System will include the following general components:

- AI-enabled cameras installed by video analytics vendor
- IP-based camera video analytics vendor
- Cloud-hosted server
- Algorithm to ingest data streams
- Traveler information dissemination

4.2 Functional Architecture and Interfaces

From a functional perspective, the Wait Time system can be broken down into three main functional areas: A) Queue Detection, B) Wait Time Calculation, and C) Wait Time Dissemination. Note that a working definition of "Wait Time" is critical to understanding the functional architecture of the system. For the purposes of this document, the wait time starts when the driver gets into the queue; it is the time until the vehicle currently joining the queue will wait before being loaded onto the ferry.

4.2.1 Queue Detection

The functional need area encompasses the detection, identification, and tracking of vehicles using roadside field units. This includes monitoring vehicles heading to, arriving at, waiting for, and boarding a vessel. The data collected under this category serves as the primary input for the wait time calculation system.

Many existing systems focus on roadside vehicle detection, and they are widely used for travel time information systems. In most travel time calculations, different vehicle types do not have a considerable effect on travel times. As such, the majority of travel time systems collect a sample of passing vehicles and aggregate the captured vehicle data in predefined time intervals to calculate average travel times between two sensors.

Wait time is often determined by sample-based systems; however, this traditional approach may not be a good fit for WSF because:

- Wait time is based on the exact number of vehicles that can fit on the ferry; sample-based vehicle detection may only provide an estimate of vehicles on the roadway
- In addition to constraints on the exact number of vehicles that can fit on a ferry, there is also a consideration needed for vehicle type composition, as vehicle loading space is limited
- WSF also expressed the need for vehicle tracking to help with identifying line cutters, emergency vehicles, and to help terminal staff manage traffic

Functional Needs of Real-time Queue Detection:

- Accurately detect the end of the queue
- Provide an accurate number of vehicles waiting in the queue
- Provide vehicle characteristics of vehicles waiting in the queue (type and dimensions)
- Recognize priority vehicles (emergency vehicles)
- Identify line-cutting

4.2.2 Wait Time Calculation

From a functional perspective, wait time calculation is the centerpiece of the TWT system, encompassing a number of processes, ingesting and fusing data from several sources, and performing the calculations necessary to provide an accurate estimate of current wait time conditions.

Functional Needs of Wait Time Calculation:

There are several key data inputs that will directly affect the wait time calculation and are therefore integral parts equation. The equation itself can be broken up into three distinct components and corresponding needs:

- **Needed Capacity Calculation** component that identifies the total capacity required to accommodate all vehicles waiting to board the ferry.
  - > Vehicle Count: The number of vehicles currently in line waiting to board the ferry.
  - > Vehicle Type and Size: Classification and dimensions of vehicles to determine space requirements.

- **Available Capacity Calculation** component that assesses the total capacity available on the next departing ferry or a sequence of ferries to accommodate waiting vehicles.
  - > Arriving Vessel Capacity: The number of vehicles that the vessel can carry in terms of space and weight. This also includes information on future arriving vessels (as scheduled) for the day.
  - > Current Occupancy: The number of reservations for the vessel, pedestrian data, emergency vehicles, and for routes with multi-stops, the number of vehicles not unloading.
  - > Capacity Restrictions: Restrictions to capacity can occur due to inclement weather conditions, low tide, and insufficient staff.
- **Matching Capacity Calculation** component that calculates the wait time for vehicles by determining the time until the capacity needed (vehicles waiting) is less than or equal to the available capacity (ferry space).
  - > Comparing the Capacity Needed (demand) with the Available Capacity, the system will assess when the demand will be equal to or less than the vessel capacity. Utilizing real-time (and scheduled) arrival data, the system will be able to provide an expected time as well.
  - > The system will perform this calculation on a continuous cycle and in predefined time intervals (such as 5 minutes).

4.2.3 Wait Time Dissemination

The wait time dissemination functional need area encompasses the methods and channels through which wait time information will be shared with various stakeholders, including passengers, terminal staff, and third-party systems.

Functional Needs of Wait Time Dissemination:

- The Wait Time System should support integration with WSF API and seamless data exchange
- The data should be provided in standardized formats
- The wait times should also be displayed on the WSF website:
  - > Mobile responsive website / or app
  - > Integrate with existing WSDOT mobile app, to leverage existing investments made in the software, as well as customer usage
- The wait times should also be available through alternative traveler information systems, including:
  - > Mainstream navigational services including Apple Maps and Google Maps
  - > Allow travelers to sign up for notifications about current wait times and any changes (such as through in-app notifications, or SMS/e-mail notifications).
- Provide a dedicated interface for staff to monitor and manage wait times (including the ability to see wait time metrics for specific lanes in the holding area to support holding area lane management).
- Automated alerts for staff regarding significant changes in wait times or other relevant events.

4.2.4 Interfaces

An interface can be defined as a point where two different systems interact. For the purposes of this ConOps, there are two types of interfaces: physical interfaces and functional interfaces. The Wait Time System will be able to leverage several existing systems and operations to improve its functionality.

4.2.4.1 Physical Interfaces

Considering the already existing physical infrastructure around terminal grounds, it is expected that a physical interface will exist between the Wait Time System vehicle detection roadside units and WSF roadside infrastructure. The availability of this infrastructure is expected to vary from terminal to terminal. As such, the Wait Time System system should be designed to use its own infrastructure by default, and the identification of this physical interface should serve as guidance information on potential opportunities.

4.2.4.2 Functional Interfaces

WSDOT API (input & output)

WSDOT operates an extensive API service designed to provide third parties with a single gateway to WSDOT's traveler information data, including real-time traffic conditions (travel times, travel restrictions, highway alerts, commercial vehicle restrictions), as well as weather information and, WSF-related information, including real-time and static vessel, terminal, schedule, and fare information.

WSDOT API Data Points that may support and enhance the TWT system include:

- Live Vessel Location Data
  - X/Y coordinates
  - Origin Terminal
  - Destination Terminal
  - Speed
  - ETA
- Static Vessel Data
  - Total number of vehicle spaces
  - Tall vehicle spaces
- Schedule Timetable Data
  - Scheduled arrival times
  - Scheduled vessel
  - Schedule adjustments/alerts
- Terminal Info
  - Parking information and rates
  - Transit connections
- Weather Information
- Alerts

Although data is readily available through the API gateway, many of the datasets will need to undergo some sort of data restructuring before they can be used for Wait Time System calculation. This may include datetime conversion and calculation, speed conversions, and may also include shortcode ID assignment to longform alert bulletin text, in order for the TWT system to effectively ingest the data into its database and consider it in wait time calculations.

In addition to ingesting data from the WSDOT API, the Wait Time System will also feed data into the gateway, including:

- Terminal Wait Times
- Real-time roadside information from field units

4.2.4.3 WSF Vessel Capacity and Schedule Modifications (input)

A functional interface to allow WSF staff to adjust vessel related inputs that are used for the wait time calculation should be explored. This would enable manual adjustments to the vessel schedule or capacity during unplanned events and restricted operations, overriding the inputs that are used during normal operations. The benefit of providing manual adjustments lies in offering human input to unplanned events where the system may lack sufficient context to accurately predict the needed adjustments. This adaptability during incidents can lead to more accurate predictions and enhance the system's overall performance.

Events Requiring Manual Input for Schedule Adjustments

Delays to otherwise on-time vessels can occur frequently and can result in varying and unpredictable delays. Often, the exact amount of delay can only be determined after the incident is resolved and the vessel departs. Manual adjustments to vessel schedule during such events would allow staff to make adjustments based on the context of the specific incident and provide accurate information to the public in a timely manner. Such events may include:

- Stalled vehicle on a vessel
- Law enforcement activity
- Medical emergencies onboard
- Adverse weather conditions

Events Causing Temporary Restrictions to Vessel Capacity

An interface for manual adjustments to vessel capacity would similarly be beneficial due to their inherent variability. For example, restrictions due to a short-staffed crew follow regulatory requirements, while those due to inclement weather are often determined by the Vessel Captain and crew. Temporary capacity restrictions may arise due to:

- Adverse weather conditions
- Short-staffed crew
- Other unexpected events resulting in restrictions

4.2.4.4 WSF Fare Collection System (input)

A functional interface with the Fare Collection system could enhance TWT system functionalities, particularly at multi-destination terminals.

- Real-time ticket sales data could enhance the precision of number of vehicles per destination, as well per reservation type

4.2.4.5 API Integration with Third-party Navigational Apps (output)

A functional interface to publish terminal wait times through an API could also be established with third-party navigation apps.

- The same API structure used for pushing data to the WSDOT API could be utilized
- Additional coordination with third-party app developers may be necessary to allow (and refine) how to incorporate the wait times into their route travel time calculation algorithm.

4.2.5 Future-Proofing Solutions

The long-term success of the Wait Time System depends on its ability to remain valuable and adaptable over time. Future-proofing, ensures the system can evolve alongside changing technologies, operational demands, and environmental factors. While risks and challenges may vary based on the technology, the core principles of future-proofing include:

1. **Modular and Scalable System Architecture**
   The system should be designed with modularity, allowing components to be upgraded or replaced individually, enabling incremental enhancements without major disruptions.
2. **Open Data Standards and API Interoperability**
   Adopting open data standards and interoperable APIs ensures seamless integration with other transportation systems and third-party platforms, enhancing flexibility and adaptability.
3. **Cybersecurity and Data Privacy**
   Cybersecurity should be integrated from the start, with regular updates to address emerging threats and ensure compliance with data security and privacy standards.
4. **Resilience to Environmental and Operational Threats**
   The system must be resilient to both environmental and operational threats, such as extreme weather and vandalism. Regular vulnerability assessments and protective measures will help ensure continuous operation during adverse conditions.
5. **Adaptability to Policy Changes and Future Regulations**
   The system must be flexible enough to accommodate future changes in regulations, policies, and service demands.

These principles serve as the foundation for future-proofing and should be adapted as needed. To ensure the system remains effective over time, these strategies must be applied throughout the project lifecycle.

Planning Stage

Future-proofing starts in the planning stage by identifying potential threats and risks, and developing strategies to mitigate them. Key risks include technological obsolescence, policy shifts, extreme weather, and financial constraints. The system should be designed for flexibility and scalability, with a preference for modular components and open data standards to avoid vendor lock-in. Built-in redundancies are necessary to ensure resilience against environmental disruptions.

Operational Stage

Once operational, regular system audits should be conducted to assess performance, hardware, and software, and to identify areas for improvement. These reviews ensure the system functions as intended, with outdated components replaced as needed. The system must also remain flexible and responsive to changes in traffic patterns, demand, regulations, and environmental conditions.

Evolving and Phasing Out

As the system matures, a structured approach is required to guide decisions on evolving or phasing out components. This approach should consider system performance, user needs, and emerging technologies. Tools like cost-benefit analysis can help determine whether to maintain, upgrade, or replace system elements.

4.3 Candidate Solutions

The uniqueness of ferry day-to-day operations, its operating environment, and the sheer number of variables that can influence wait times, means and that no single turn-key solution is available on the market that can fully address the project's needs and goals.

Several solutions to address the functional requirements exist in the marketplace. In the development of this ConOps, a list of hardware, software, and data integration solutions were evaluated, for preliminary alignment with project goals. A detailed review of available technologies and solutions is presented in the companion technical memoranda for the ConOps project; refer to Task 3: Market Research Technical Memorandum for additional information.

A summary of the technologies, devices, solutions and vendors reviewed in the development of this ConOps is presented in ***Table 4.***

The technologies and solutions recommended as most likely to address at least a portion of the project requirements are indicated with an asterisk.

Table 4 Vehicle Detection Technologies

Solution Type	Pros	Cons	Vendors
AI-enabled Cameras*	• Highly flexible in detection and configuration (e.g., what to detect, where to detect, what information to extract) • Ability to re-identify vehicles at later points along a route • Straightforward deployment; often only requires a PoE connection • Provides visual confirmation of vehicle queues in addition to data extraction • Custom event detection setup (e.g., road conditions, weather) • On-board video processing enhances privacy (no need for video feed to leave the device)	• Public perception concerns • Potential vendor lock-in due to proprietary hardware and required yearly licenses	• AY Waysion • Armada • Blissway • Hanhwa Vision • Invision • Rekor
IP Cameras + Video Analytics*	• Compact deployment footprint • Cost-effective; can match AI-enabled cameras in capability • Potential to use existing high-definition IP cameras • Continuous improvement in detection/operations through deep learning	• Effectiveness depends on camera resolution and proper angling • Requires strong network connection for high-quality video transmission • On-premise processing demands significant computing power	• Viso.ai • Cohu • FLIR • Intuvision • Traffic Vision • Genetec • Cisco systems
Radar	• Longest range of high-precision object detection (comparable to LiDAR) • No PII concerns • Effective in most weather conditions • Low power needs	• Requires a supplemental processing hub in the field • Limited vehicle identification (usually only by class) • Cannot re-identify vehicles • Detection is challenging in prolonged, complete standstill traffic	• FLIR • HIKVision • SMATS • Sensys • Transcore

Solution Type	Pros	Cons	Vendors
RFID	• High accuracy in detection • Potential integration with point-of-sale systems to extract additional traveler data (e.g., destination, reservation status) prior to the vehicle arriving at the tolling booth	• Requires RFID transponders • Short operating range, limiting insight into conditions ahead of the antenna • No information on vehicle type	• Kapsch • Transcore • Omron • Schedit & Bachmann • NXP Semiconductors
Wi-Fi	• Low tech-low profile deployment means straightforward installation	• Susceptible to noise, making filtering challenging in low-speed environments (e.g., distinguishing between pedestrians and standstill traffic) • Newer smartphones use rotating MAC addresses, reducing the effectiveness of MAC address matching along the route	• DeepBlue • Iteris • Geotab • Cubic • SMATS
Bluetooth	• Low-tech, low-profile deployment enables straightforward installation • Can detect Bluetooth radios in cars (active, passive connections, and BLE), reducing the impact of rotating MAC addresses in newer devices	• One of the lowest detection percentages among listed technologies • Similar to Wi-Fi, susceptible to environmental noise, making filtering challenging in low-speed environments	• DeepBlue • Iteris • SMATS • HID Global (Bluvision) • Conduent Transportation
LiDAR	• Longest range of high-precision object detection (comparable to radar) • Provides high-definition point cloud views of road conditions while ensuring PII safety • Effective in most weather conditions • Low power needs	• Requires a supplemental processing hub in the field • Effective vehicle detection becomes challenging in prolonged standstill environments • Costly hardware • Data processing setup and modification can be complex	• Cepton • Ouster • Luminar • Aeva • Innovision • Graf Industrial Corp (Velodyne)
Loop sensor	• Least susceptible to weather conditions • Relatively straightforward deployment if using wireless pucks	• Intrusive field deployments, even with pucks • Data is limited to vehicle counts and possibly class (based on axle detection) • Vehicle detection decreases in standstill traffic	• Sensys • Econolite • Trafficware • TransCore • Kapsch

05 Procurement Concept

5.1 Summary

There are several viable options to procure the system described in this ConOps. Much of this document is focused on dealing with the complexity of the terminal system overall. A concept that works for many of the terminals that share common features has to also work for the terminals with special conditions. The system has to be designed and implemented with the flexibility and vision to accommodate a complex operational and geographical environment, as well as a list of stakeholders that spans public users and several groups within WSF. In terms of data collection, different types of hardware, sensors, and communications may be necessary at different terminals. On the other end, the data disseminated through various channels will serve different purposes for a variety of stakeholders.

Given the requirements and complexities outlined, a structured procurement approach is crucial to ensure successful implementation of the system integrator and solutions providers. The strategy should focus on effectively managing both components, addressing the need for different capabilities, and ensuring that all requirements are met.

Role of System Integrator and Solution Providers

In this procurement strategy, the System Integrator plays a central role. The system integrator is responsible for overseeing the entire project, ensuring that all components from various solution providers work in harmony. This includes the selection and management of vendors who offer hardware, software, and data integration solutions crucial for accurately detecting and reporting vehicle queues and wait times. The system integrator's leadership is essential for ensuring that all parts of the system are effectively integrated and that the project meets its goals. Their role extends to managing the interface between different technology providers, troubleshooting integration issues, and ensuring that the final system performs as intended.

The procurement concept presented in this ConOps has been carefully developed, with attention given to several different approaches. A single vs. multi-contract approach was considered, illustrated in ***Table 5.***

Table 5: Procurement Options

Solution Type	Pros	Cons
Single Contract	• Simplifies management and coordination if one vendor can handle all aspects. Useful for smaller projects or where a single vendor can provide end-to-end solutions. • Shorter Implementation time • System Integrator takes the risk of selecting the right solutions providers	• Risk if the vendor fails to meet requirements or if their capabilities do not fully align with needs.
Multiple Contracts	• Allows specialization and expertise in each component (e.g., one vendor for data collection, another for mobile app development). Reduces risk by dividing responsibilities.	• Requires more coordination and management effort to ensure all components work together seamlessly. • Longer Implementation time

The recommendation for WSF is to select the single contract solution, with a team led by a system integrator, supported by a vendor or group of vendors. The contract should be developed with the flexibility necessary for the lead contractor to add additional vendors as necessary. The lead contractor will be responsible for developing a team of vendors who satisfy as many of the functional and technical requirements as possible. However, there must be accommodations made for a situation were the operational or geographical limitations of one or more ferry terminals necessitates the addition of a different technology that cannot be delivered by any of the participants of the primary contract.

5.2 Acquisition Strategy

Working with the various internal stakeholders, developing high-level requirements for the system-wide Ferry Terminal Wait Time Traveler Information System is key in identifying real-time vehicle congestion conditions, provide predictive modeling, support automated communication to travelers, and integrate with third-party navigational tools. These requirements are key to the acquisition strategy.

Given the project's complexity and the necessity for specialized expertise, a single step/single contract procurement approach is recommended. This involves issuing a combined Request for Proposal (RFP) that includes requirements for both the system integrator and solution providers. The RFP should request detailed proposals from vendors, evaluating them based on their technical approach, cost-effectiveness, and alignment with the project's objectives.

To ensure the selection of the most capable vendors and to mitigate risks, the procurement process should incorporate a pilot phase. This pilot will allow WSF to assess the practical capabilities of the chosen vendors before committing to a long-term contract. Key steps in this process include:

Evaluating System Integrators: Review and assess proposals for their technical strategies, integration plans, and project management capabilities. This ensures that the system integrator can effectively coordinate all components and manage the project from start to finish.

Assessing Solution Providers: Examine detailed proposals for specific components of the system, such as queue data collection and video analytics capabilities. This ensures that each component meets the required specifications and integrates smoothly with the overall system.

Conducting a Pre-Bid Meeting: Organize a pre-bid meeting at one of the terminals to provide vendors with a clear understanding of the operational environment and project requirements. This will enable vendors to prepare more accurate and relevant proposals.

By adopting this single-step and single contract approach, WSF can streamline the acquisition process, manage risks more effectively, and ensure that the final system is cohesive and fully meets the project's requirements.

06

Implementation Concept and Schedule

6.1 Implementation Summary

The estimated schedule to procure design, deploy, implement and pilot the Wait Time System is approximately 18 months. The steps to implement are illustrated in ***Figure 12.***

Wait Time System Implementation Plan

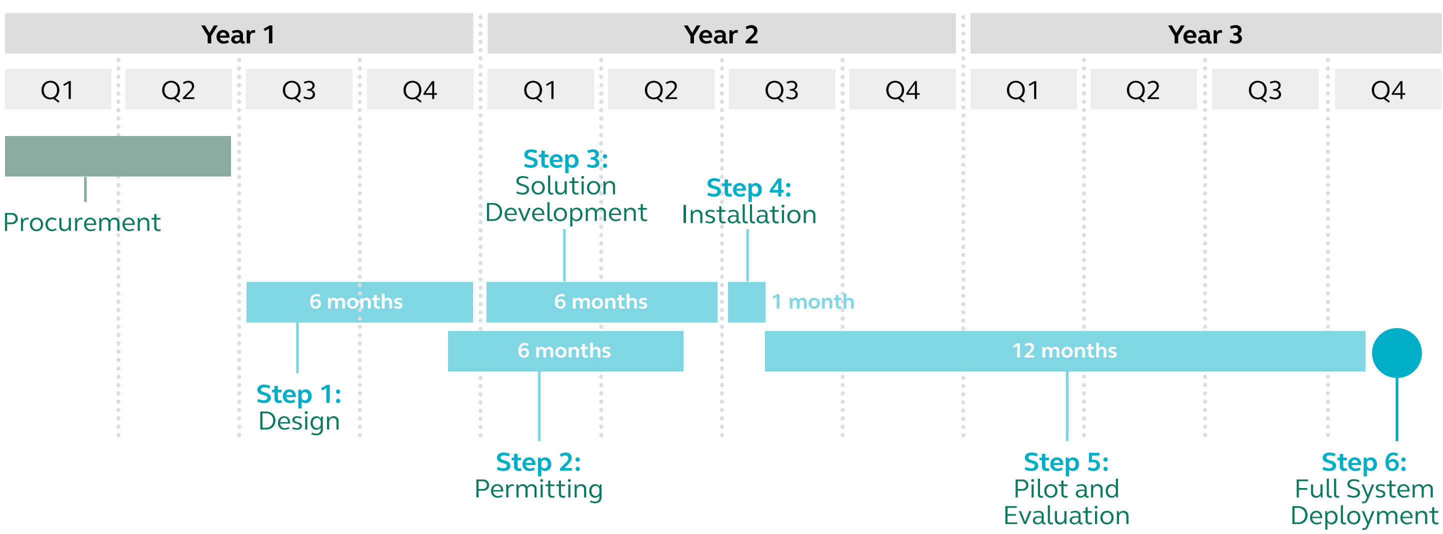


Figure 12: Implementation Timeline

6.2 Implementation Steps

Procurement

The procurement process is estimated to take six months. During this time, Washington State Ferries will oversee development of procurement documents, the release of an RFP, evaluation of proposals, and negotiation with the selected team. The procurement concept described recommends a system integrator be responsible for the design, implementation, testing, and deployment of all equipment, systems, software and networks to provide a fully functioning system. A foundational component to the successful implementation will be an interactive design process. The systems integrator will be responsible for demonstrating the system components, and how those components work together to address the functional requirements. The systems integrator will direct and manage the various vendors selected to provide the solution.

Step 1: Design

The implementation process will begin with the design phase. This phase will be interactive with WSF stakeholders, and iterative as initial design concepts are shared, evaluated and improved upon as the process proceeds. The systems integrator will lead the design process. This will include a detailed review of the unique conditions present at many of the terminals.

The systems integrator will develop a System Design Document. The document will identify the components of both the **"Generalized Model"**, the unique elements of the **"Specialized Model"**, and the components of the **"Reservation Model."** The **Generalized Model** will include system functions such as the collection of vehicle queue data, integration with AIS and other data streams, and the dissemination of traveler information. Design elements of the **Specialized Model** will include such considerations, multi-destination data, and the distinguishing of city traffic from ferry terminal traffic. The **Reservation Model** will address the needs and data environment of the reservation terminals. The System Design Document will cover both the field device component as well as the backend software integration and dissemination component. The Design Document will not be finalized until after Step 2.

Timeline: Step 1 is estimated to take 6 months.

Step 2: Permitting and Municipal Coordination

The draft system design will include a list of recommended device and hardware solutions. This ConOps includes the recommendation that the devices supporting AI-enabled cameras using edge computing are the most likely to successfully deliver the functionality required. However, coordination with the cities or municipalities that mange the right of way will be key. Installation of new hardware will need to be properly permitted, and that permitting will require the engagement and buy-in of those partner agencies. The permitting situation will drive the pilot planning; where hardware can be most easily and efficiently permitted will determine where the system is piloted. This step will include the selection of one or more locations to pilot the system.

Timeline: Step 2 is estimated to take 6 months.

Step 3: Solution Development

According to the guidance developed for the System Design Document, the systems integrator will design, develop, test and implement the backend software needed to integrate all Wait Time System and complementary data streams.

Timeline: Step 3 is estimated to take 6 months.

Step 4: Device Installation

The systems integrator will manage and supply all installation activities at the locations selected for the pilot. Installation activities must be characterized by minimal disruption to regular operations of the selected terminals. The System integrator will be responsible for coordinating all installation activities with WSF management and terminal staff.

Timeline: Step 4 is estimated to take 1 month.

Step 5: Pilot and Evaluation

The Wait Time System will be piloted at the Mukilteo Ferry Terminal. Mukilteo is a recommended pilot location because it falls within the 'generalized' model with a single destination route, holding space for waiting vehicles, and options for alternate routing. The pilot will include ongoing evaluation, with input solicited from WSF terminal and Customer Service staff, as well as public surveys.

The pilot will be designed with maximum flexibility, to support expansion during the subsequent phases of system deployment.

Timeline: Step 5 is estimated to take 12 months.

Step 6: Full Deployment

Taking lessons learned from the pilot phase, the system integrator will plan and execute an expansion systemwide, throughout the 20 terminals. The System Design Document developed in Step 1 will help guide the implementation plan and timeline for an effective rollout of the system to a terminals falling under both the 'generalized' and 'specialized' model.

6.3 Pilot Deployment / Mukilteo

With the preliminary implementation steps complete, and the design document guiding installation and deployment, the most efficient way to test the concept is to deploy a pilot. A pilot will allow WSF to conduct a proof of concept on the system's architecture and operations. This ConOps includes the recommendation that a Wait Time System begin with a pilot at the Mukilteo ferry terminal. Mukilteo, as one of the terminals categorized in the 'generalized model' as it meets the following conditions:

- Single destination route (Mukilteo – Clinton)
- Existing holding area, with space for 250 vehicles
- The largest ferry serving this route has a capacity of 144 vehicles
- Drive-up space estimates are currently provided by WSDOT
- Alternate routing is available; drivers can choose instead to drive a northern route

Permitting

The hardware necessary to operate in the field will need to be permitted. It is assumed that a deployment at Mukilteo will necessitate a permitting process, and coordination with the owners of the city streets around the terminal; both Mukilteo City and Snohomish County.

Environmental Characteristics

Low tide conditions can create restrictions in the loading of long, low clearance vehicles, or even cancellation of a sailing. Ferry service can be affected by tide conditions and will continue to be monitored by operations staff.

Infrastructure and Terminal Characteristics

Mukilteo has just two ferries that service the port, traversing the route from Mukilteo to Clinton and back. This terminal has holding lanes, which can accommodate 30-35 vehicles in each lane on average. There are several CCTV deployed at the terminal, and those cameras will help the project leverage existing infrastructure where possible. Where images are of high enough resolution and viewing angle to be useful for a video analytics process, those cameras will be put to work.

Figure 13 Pilot Deployment Map

Line cutting is a significant problem at this ferry terminal. The first iteration of the Wait Time System, deployed for a limited time at the Mukilteo terminal, will be the first to identify vehicles who cut in line, and use that data as input to the algorithm. Knowing terminal staff are not allowed to interact with a customer who is breaking the rules and may become belligerent, the Wait Time System will have the ability to alert local law enforcement when such an opportunity arises.

Other factors that can impact vehicle queue and in turn wait times include special events, boat availability due to maintenance, both scheduled and unscheduled, and broken-down vehicles.

In terms of physical infrastructure, this terminal has plenty of existing WSDOT fiber, as well as power poles on which additional devices can be installed. Existing power / lighting / CCTV poles are available throughout the holding area, through the length of the historical queue areas. There is a server rack in the Terminal building, which will greatly benefit the pilot deployment.

Implementation

AI-enabled cameras will be installed at the locations indicated in Figure 9. The cameras installed at the terminals will run an AI software application. The application will collect queue measurements, vehicle identification data, and vehicle classification. The pilot will also make use of the IP-based cameras already installed at the terminals. Where images are clear enough from those cameras to serve as input for the video analytics engine, those images will be used as data to support the wait time calculation.

Lidar /Radar along with Wi-Fi technology will be deployed to supplement the AI-enabled cameras for vehicle detection and classification. The data collected by the lidar/radar/Wi-Fi will serve as an input to the central system and will be used to support the wait time calculation.

The central system will reside on premises, in the Mukilteo terminal building or in the cloud. The central system will receive data from roadside peripherals (CCTV cameras, lidar/radar, Wi-Fi), and vessel data such as arrival and departure times from the WSF API. The wait time algorithm will reside in the central system and will use the data received from the roadside and WSDOT API to perform and dissipate wait times. The following system architecture diagram depicts an example of a pilot system.

07 Operations and Maintenance

7.1 IT and Technical System Support

To ensure the Wait Time System is maintained effectively, a core feature will be a Maintenance Online Management System (MOMS). MOMS is an integral component that will provide real-time monitoring of each Wait Time System component and data on the integrity of all the communications. When an event is detected anywhere in the system, MOMS will alert designated parties and assign a priority to the detected event based on severity. MOMS can be configured to send notifications to multiple technicians & designated WSF contacts and will escalate notifications if an alert is not acknowledged within a configurable amount of time. MOMS will also provide asset, incident, scheduling, and records management. When an alert necessitates the creation of a work order, MOMS automatically creates the work order and tracks it to completion. MOMS also functions as a historical database of the Wait Time System's performance, planned and unplanned downtime, and all maintenance activities. This database will provide WSF with simple and quick access to any maintenance record at any time. Maintenance technicians benefit significantly from the instant access to previous and ongoing maintenance activities that MOMS provides. Historical maintenance data can also help identify broader anomalies and trends in equipment failures.

7.2 Performance Monitoring

A MOMS System includes advanced diagnostic tools to analyze the Wait Time System's performance in depth. Typically, MOMS will use a combination of standard reports and custom reports to satisfy all WSF reporting requirements.

Report categories include:

- Availability and Reliability
- Inventory Management
- Administration
- Work Order Tracking
- Preventive Maintenance Management

7.3 Alerts and Notifications

MOMS monitors all the system components including communications, hardware, and software, providing maintenance personnel with real-time data on equipment health, faults, and status changes and facilitating timely resolution of detected issues. When MOMS detects anything problematic, it sends alerts to distribute email and/or text notifications to designated personnel.

Notifications can be configured to automatically generate work orders. Alerts in the MOMS are fully configurable, allowing users to specify delivery methods (email, text/SMS), recipient lists, message content, escalation actions, and other parameters on a per-alarm basis. Alerts support thresholds, tolerances, alert types, alert frequency, delivery method, recipients of specific alert types (including the capability to send notifications to third parties), and many other configurable options.

7.4 Work Order Creation and Tracking

As noted, MOMS generates an alert upon any detected fault or issue across the Wait Time System. Certain alerts can be configured to automatically generate a work order and authorized users can generate work orders manually if needed (to address any issues not detected by MOMS). Work orders may be assigned automatically or assigned manually by an authorized user. Work orders are tracked through a series of states including creation, assignment and notification, work started, work completed, work suspended, and approved or closed. Work orders are updated with the details of the maintenance activity, including the arrival and departure time at the scene of the issue, parts removed, replaced or installed.

7.5 Types of Maintenance

The Wait Time System will comprise predictive, preventive, corrective, and emergency maintenance. The approach to providing each of these types of maintenance is listed below.

- Predictive maintenance – Analysis of monitoring data to identify trends/faults before they occur; proactively replacing or upgrading equipment which is nearing end-of-life.
- Preventive maintenance – Regular, recurring equipment inspections and proactive maintenance activities to keep system components operating at peak performance levels.
- Corrective maintenance - Diagnostic and repair service after an unexpected failure occurs with the objective to return the failed component to operation.
- Emergency Maintenance - Repair, restoration or replacement of major hardware or software components after a catastrophic event (power failure, damage due to extreme weather or car accident, etc.).

Examples of Predictive Maintenance that can be incorporated include:

- Analyzing historical maintenance data tracked in MOMS to help identify trends in equipment failures or system anomalies.
- Leveraging reporting and analysis tools to gain deep insights on the lifecycle, costs, and maintenance trends for each Wait Time System component that is monitored by the MOMS.
- Evaluating system performance data and optimizing configuration to maintain performance levels
- Identifying equipment which is nearing obsolescence and sourcing replacement.

Examples of Preventive Maintenance include:

- Updating configuration/installation settings as needed.
- Inspecting cabinets and field switches.
- Cleaning CCTV camera lenses
- Cleaning Lidar/Laser/Radar unit lenses

Examples of Corrective Maintenance include:

- Replacing failed field components (i.e. CCTV Cameras, Lidar/Laser/Radar units)
- Replacing failed server components
- Replacing failed network components (i.e. field and core switches)

Examples of Emergency Maintenance include:

- Replacing entire cabinet and field components after major accident such as a car crash

7.5.1 Maintenance Priority Levels

Wait Time System maintenance priority levels are divided into four (4) levels as described in the following Table.

Priority	Description
1	Any maintenance event that causes loss of data; including the capturing of vehicle queue information.
2	Any maintenance event that cuases the delay of data from the local system to the central system.
3	Any maintenance event for a redundant Component or non-critical Component.
4	Scheduled preventative maintenance event.

All maintenance activities are typically assigned one of these four priorities and will be escalated and tracked in a manner consistent with each Priority Level.

7.5.2 Staff

To meet Wait Time System maintenance performance maesures, maintenance staff will consist of two levels, one (1) and two (2). Level one consists of local on-site field technicans to perform both hardware and software tasks. Level two consists of Subject Matter Experts (SMEs) who will remotely support level one technicians when more complex maintenance or system perfomance measures need to be performed.

7.6 Performance Measures

The Wait Time System will continuously maintain and operate in accordance with three performance levels for each performance criteria or measure: Pilot, Implementation, and Maintenance Level. The Pilot level performance measures will have a reduced requirement. The Maintenance level, or final system deployment, performance measures requirements are greater than or equal to the Pilot level requirements and represent the desired performance level of the Wait Time System during its operation and maintenance.

Within both levels exist three different types of performance measures that determine the timing on when the levels begin and end. These three types are Field Equipment, Terminal System (application/SW), and Central System (application/SW). Field Equipment performance is measured per facility and are linked to the performance and functionality of the equipment and communications within the field equipment system. Terminal System measurements are facility dependent. Central System measurements are independent of any one facility and are linked to the performance and functionality of the complete Wait Time System.

Measurement and assessment of performance measures begin at the pilot level. Performance measures are met from the pilot level throughout the implementation period until the Wait Time System enters the maintenance period.

Throughout the pilot, implementation, and maintenance period, the Wait Time System shall meet performance measures.

Performance monitoring will be facilitated by reporting performance in clearly measurable and easy to understand terms and reports. The measurement of these performance criteria shall be automated where possible and shall be straightforward and data driven. The methods and results of the measurement process shall be fully subject to independent audit and will be utilized to trigger timely action to correct any deficiencies and failures to meet required availability, accuracy, and performance requirements.

Actual performance is defined and measured against the requirements and defined time periods to assess the availability, accuracy, and performance of the Wait Time System. The following are the major levels of performance criteria:

1. **Availability**
2. **Accuracy**
3. **System Performance**
4. **Maintenance (Response/Repair timing)**

7.6.1 Performance Criteria

The major levels of performance measure criteria are defined in the following table.

Table 5 Performance Measures Criteria

Performance Criteria	Description
Availability	A percentage assigned that defines the availability of each HW component. Availability defined as equipment or application uptime or time without degradation.
Accuracy	Performance measures are used to assess the correctness of the Wait Time System outputs. To determine accuracy, some measures require taking enough samples to demonstrate the criteria is met at a specified confidence level. Other accuracy requirements are measured by comparison to external measurement systems or devices (i.e. radar gun for speed).
System Performance	Measure the performance of various SW processes including Data flow.
Maintenance	SchResponse and Repair Time performance measures will be measured and reported on during the maintenance level. Response time is measured starting from the time the party responsible for maintenance receives notification of the inquiry, maintenance events or failures, and ending when a maintenance technician arrives at the site of the problem or acknowledges the associated alarm or alert in the MOMS application. Repair time is measured from the time when the party responsible for maintenance receives notification of the maintenance events or failures and ending when the failure condition is corrected, and the system is returned to normal operation. .

08 Risk Management

As with all technology projects, risk management will play a crucial role in supporting efficient project delivery throughout the planning, design, implementation and operations of the Wait Time System. The Wait Time System will be characterized by an environment with many unique components, a complex distribution of technology types, and the integration of many different types of data. The project will include technical, organizational, schedule and budget risk. Anticipating and managing risks that could impact achievement of project goals is expected to be a foundational process as the Wait Time System is deployed.

The systems integrator responsible for system delivery will create a standard Risk Management Plan, with content tailored to the needs of this project. The Risk Management Plan will include a section stating the deployment and operational goals of the project, and all subsequent risk management activities will seek to maintain alignment with those goals.

The systems integrator will kick off the risk management effort by conducting a Risk Workshop, where risks are identified by project stakeholders and documented in a Risk Register. This Risk Register will be the central clearinghouse for identified risks in such general areas as technical, budget, and schedule risk; although other categories will likely be identified. The Risk Register will provide clarity and consistency to all project stakeholders, and will be updated according to clear and agreed-upon metrics.

A sample Risk Register is provided in Appendix B.

Appendix A: High-level Functional Requirements

Functional Requirements have been derived from and developed to address needs as they were collected through various phases. These phases included the following:

- A review of existing studies and documentation and market research.
- Stakeholder interviews with WSF staff representing Communications, Customer Information, Environmental, Terminal Operations, and Information Technology.
- Project staff site visits of several terminals to gather first-hand knowledge of various operational environment and challenges.

The list of functional requirements includes several standard categories of information, necessary to properly identify, track, and update functional requirements. It is imperative to distinguish between the objective of the functional requirements list developed for this project, and a more formal and technical Systems Requirements document which is a necessary step post-ConOps. The list developed for the WSF Wait Time System is a high-level list of functions the system must perform, in order to achieve the vision of the ConOps. The functional requirements describe 'what' the system will do, but not 'how' the system will do it.

WSF Wait Time ConOps / High-Level Functions				
Function ID#	Function	Requirement Category	Priority: Need / Enhancement	Component
General Functionality				
1	The Wait Time System offers a precise approach for collecting, analyzing, and reporting queue lengths and wait times at terminals.	General Functionality	Need	Detection
2	The Wait Time System performs automated wait time measurements that complement and enhance existing city and highway congestion data.	General Functionality	Need	Calculation
3	The Wait Time system helps distribute demand for ferry services across different times of day and integrates with other transportation networks that have available capacity	General Functionality	Need	Dissemination
4	The Wait Time system provides data that encourages shifting discretionary trips from peak demand periods to times with lower utilization.	General Functionality	Need	Dissemination
5	The Wait Time System supports adaptive management strategies to handle demand more cost-effectively, such as redirecting trips to alternative modes of transportation or less busy travel times	General Functionality	Need	Dissemination
6	The Wait Time System enhances trip planning by offering options for alternative routes and modes of travel, including the best route choices and wayfinding assistance.	General Functionality	Need	Dissemination
7	The Wait Time System ingests terminal-specific specialized data.	General Functionality	Need	Calculation
8	The Wait Time System considers terminal tide current conditions and impacts.	General Functionality	Need	Calculation
9	The Wait Time System communicates travel delays, wait times, and incident information via information boards and VTMS throughout the terminal area.	General Functionality	Need	Dissemination
System Functions				
10	The Wait Time System identifies the end of the queue and accurately reports its length.	System Functions	Need	Detection
11	The Wait Time System provides real-time updates on the number of vehicles currently in the queue.	System Functions	Need	Detection
12	The Wait Time System is equipped with the necessary hardware to precisely collect, analyze, and report queue lengths and wait times at terminals.	System Functions	Need	Detection
13	The Wait Time System detects vehicles that have bypassed the queue and cut in line.	System Functions	Need	Detection
14	The Wait Time System recognizes and prioritizes vehicles such as medical transports, school groups, and emergency vehicles.	System Functions	Need	Detection
15	The Wait Time System incorporates the estimated arrival time of the next vessel into its wait time calculations for more accurate predictions.	System Functions	Need	Calculation
16	The Wait Time System includes automated passenger counting capabilities.	System Functions	Enhancement	Detection
17	The Wait Time System's calculations account for reservation holders who may not yet be at the terminal.	System Functions	Need	Calculation
18	The Wait Time System prioritizes reservation holders over non-reservation holders.	System Functions	Need	Calculation
19	At terminals with separate standby lanes for each destination (e.g., Anacortes), the Wait Time System monitors these lines in the holding area and reviews upcoming sailings with reservations to estimate available space for non-reservation passengers, providing more accurate wait time estimates.	System Functions	Need	Detection, Calculation
20	The Wait Time System accounts for delays caused by intersecting train traffic.	System Functions	Need	Calculation
21	At multi-destination terminals, the Wait Time System includes identification of the separate queues and includes these assumptions in the calculations.	System Functions	Enhancement	Detection, Calculation
22	At terminals with holding areas outside of the terminal proper (i.e. Kingston), the wait time system monitors the capacity of the holding area and accounts for these vehicles for wait time calculations.	System Functions	Need	Calculation
23	The Wait Time System will distinguish staged vehicles from waiting vehicles	System Functions	Need	Calculation
Software / Application				
24	The Wait Time System features a network of servers, hosted securely in either a public or private cloud, configured to ensure the seamless and accurate operation of all subsystems and to effectively manage terminal wait times.	Software / Application	Need	Operations
25	The Wait Time System includes built-in redundancy and robust disaster recovery capabilities.	Software / Application	Need	Operations

WSF Wait Time ConOps / High-Level Functions				
Function ID#	**Function**	**Requirement Category**	**Priority: Need / Enhancement**	**Component**
26	The Wait Time System integrates software components necessary for managing physical components, generating and overseeing wait time measurements, and ensuring real-time communication both internally and externally.	Software / Application	Need	Operations
27	The Wait Time System gathers data, provides real-time information, forecasts traffic patterns, and generates detailed reports.	Software / Application	Need	Operations
28	The Wait Time System predicts traffic conditions using historical data.	Software / Application	Enhancement	Operations
29	The Wait Time System distributes travel wait times via travel alerts, schedules, websites, apps, and social media.	Software / Application	Need	Information Dissemination
30	The Wait Time System provides real-time information based on sailing schedules/actual sailing departures.	Software / Application	Need	Information Dissemination
31	The Wait Time System features an operational dashboard tailored to various user types, including terminal staff, operations center personnel, planners, and leadership, with customized levels of information for each.	Software / Application	Need	Information Dissemination
32	The Wait Time System supports the detection and reporting of key events within the terminal, including 1. Vessel emergency (i.e. rescue mission and ferry gets pulled) 2. Medical emergency 3. Police law enforcement activity 4. Broken down vehicles	Software / Application	Need	Detection
Traveler Information Dissemination				
33	The Wait Time System includes a mobile app that offers real-time terminal wait times and provides users with alternate route information.	Traveler Information Dissemination	Need	Information Dissemination
34	The Wait Time System provides the estimated wait time to board	Traveler Information Dissemination	Need	Information Dissemination
35	The Wait Time System provides the estimated next sailing time the user can expect to board.	Traveler Information Dissemination	Need	Information Dissemination
36	The Wait Time system provides alternate routing suggestions for the terminals where alternate routes are possible.	Traveler Information Dissemination	Need	Information Dissemination
37	The Wait Time System provides messaging to WSDOT and partner VMS	Traveler Information Dissemination	Need	Information Dissemination
38	The Wait Time System provides alerts to terminal staff when a threshold of waiting vehicles is reached.	Traveler Information Dissemination	Need	Information Dissemination
Vehicle Detection				
39	The Wait Time System performs volumetric classification of vehicles.	Vehicle Detection	Need	Detection
40	The Wait Time System detects and reports vehicle occupancy.	Vehicle Detection	Enhancement	Detection
41	The Wait Time System detects line cutters.	Vehicle Detection	Enhancement	Detection
Performance				
42	The Wait Time System adheres to established performance measures for Roadside Equipment (hardware).	Performance	Need	Operations
43	The Wait Time System complies with the established performance measures for the Central System (software).	Performance	Need	Operations

WSF Wait Time ConOps / High-Level Functions				
Function ID#	Function	Requirement Category	Priority: Need / Enhancement	Component
44	The Wait Time System's performance measures: - Are Reported monthly. - Are automated whenever possible. - Trigger timely actions to address deficiencies and failures. - Are subject to independent audits. - Are conducted in accordance with defined sample sizes	Performance	Need	Operations
45	The Wait Time System's performance criteria include ensuring system accuracy.	Performance	Need	Operations
46	The Wait Time System's performance criteria mandate consistent and high system availability	Performance	Need	Operations
47	The Wait Time System's performance criteria include metrics that measure the effectiveness of its various software processes	Performance	Need	Operations
48	The Wait Time System's performance criteria include metrics for maintenance, specifically response and repair times.	Performance	Need	Operations
Security				
49	The Wait Time System will integrate comprehensive security plans, policies, and procedures, all aligned with WSDOT policies and standard	Security	Need	Operations
50	The Wait Time System will be designed to comply with the NIST 800-53 Privacy Baseline and Security Control Baseline for moderate-impact systems.	Security	Need	Operations
51	Vulnerability scans are conducted to assess security risks to the system, identify potential vulnerabilities, and address them proactively	Security	Need	Operations
52	The Wait Time System incorporates access control functions and measures to safeguard system integrity and data security	Security	Need	Operations
53	Access control system functions include: 1. Account monitoring 2. Whitelisting: Restricting access to authorized users and systems. 3. Privileged Access Management (PAM): Managing and monitoring high-level access to critical systems. 4. Domain Authentication: Implementing domain-based authentication on the Central Server. 5. SD-WAN/Modems: Utilizing secure SD-WAN and modem configurations. 6. IP Cameras: Deploying IP cameras with Lightweight Directory Access Protocol (LDAP)/Radius support for enhanced security. 7. Centralized Authentication: Implementing centralized authentication for streamlined user access management.	Security	Need	Operations
54	Access control includes but is not limited to: 1. Intrusion Detection and Prevention: Monitoring and blocking unauthorized access attempts. 2. Anti-Malware: Protecting systems from malicious software. 3. Access Control Lists (ACLs): Defining permissions and access levels for users and systems. 4. Firewalls: Filtering and controlling network traffic to safeguard against external threat	Security	Need	Operations
55	The Wait Time System will employ industry best practices for data encryption to ensure robust protection	Security	Need	Operations
56	Data encryption is ensured through the use of an IPSec VPN tunnel for secure communication between field devices and the cloud. It covers all data, including personal identifiers like license plate or transponder information, ensuring encryption both at rest, in use, and in transit	Security	Need	Operations
57	Authentication includes user access management with Multi-Factor Authentication (MFA). The system also employs LDAP/Radius for authentication wherever feasible.	Security	Need	Operations
58	The Wait Time System incorporates permission controls to regulate access to system controls, files, directories, and software applications.	Security	Need	Operations
59	Compliance standards include: 1. National Institute of Standards and Technology (NIST) 2. Cybersecurity & Infrastructure Security Agency (CISA)	Security	Need	Operations

WSF Wait Time ConOps / High-Level Functions				
Function ID#	**Function**	**Requirement Category**	**Priority: Need / Enhancement**	**Component**
60	The vendor assigns key personnel specifically dedicated to the Wait Time project.	Staffing	Need	Operations
Maintenance Online Monitoring System (MOMS)				
61	The Wait Time System: -Continuously monitors all devices through constant polling. -Detects and reports all failures and faults. -Provides detailed performance reports. -Generates and manages repair and trouble tickets/work orders. -Supports the stacking of multiple trouble tickets/work orders. -Issues alerts and notifications for timely responses.	Maintenance Online Monitoring System (MOMS)	Need	Operations
62	The Wait Time System encompasses three types of maintenance: -Predictive: Utilizing automation and artificial intelligence to anticipate and address potential issues before they occur. -Preventive: Conducting regularly scheduled maintenance to prevent problems and ensure system reliability. -Corrective: Implementing emergency maintenance to quickly resolve unexpected issues and restore functionality.3. Corrective - Emergency maintenance	Maintenance	Need	Operations
Environmental				
63	Permits and approvals may experience delays. The vendor will proactively initiate coordination for necessary permits and approvals, including negotiating with local jurisdictions for specific hardware solutions	Environmental	Need	Operations

Appendix B:
Sample Risk Register

Washington State Ferries / Wait Time System Risk Register											
Risk Register											
Consultant Name	WSF System Integrator									Last Updated	01-Jan-25
#	Risk Title	Risk Description / Impact	Identified Date	Risk Category	Status	Owner	Impact 1-5	Probability 1-5	Total Score	Possible Mitigation	Date Closed
001	Risk 1			Technical	Open	IT Lead	1	3	3	1. Mitigation step 2. Mitigation step	
002	Risk 2			Operational	Open	Project Manager	2	5	10	1. Mitigation step 2. Mitigation step	
003	Risk 3			Budget	Open	System Integrator	2	3	6	1. Mitigation step	

LOW 1 2 3 4 5 6 7 8 9 10 HIGH

Risk Register Levels

Appendix C:
Policy and Regulatory Considerations

Several federal laws and standards have relevance for determining wait times and/or affect wait times; namely those from the US Coast Guard and US Customs and Border Protection (US CBP). These are described below:

US Coast Guard[1]

- **Vessel size requirements and impact on capacity:** Depending on the specific vessel and route, a maximum number of passengers and crew members is allowed to ensure vessel stability. The Coast Guard stipulates the maximum number of passengers based on the number of available seats, the square footage of open space, and/or the amount of rail space available. A certain number of lifesaving appliances are also required on board and are stipulated for each vessel. Awareness of the capacity of each vessel leaving the terminal, particularly if last minute vessel changes need to be made, may affect the wait time depending on the difference in capacity of vessel being substituted.
- **Accessibility requirements related to the Americans with Disabilities Act (ADA) and impacts to passenger vessel design and capacity planning:** While there are currently no specific requirements for ADA on passenger vessels, draft accessibility regulations have been drafted by the U.S. Access Board and may come into play in the near future. Once they are adopted, although a date of adoption is currently unknown. The proposed guidelines include regulations for onboard circulation, vertical access between decks, doorways, thresholds, restrooms, and other passenger spaces and elements. When adopted, the guidelines may impact passenger vessel design as well as change passenger capacity, which, in turn, can affect wait times in the long-term.
- **Environmental restrictions related to speed:** On certain routes, ferries may travel through designated slowdown zones that may reduce the speed at which vessels can travel or result in fewer service trips. Sometimes these zones are unpredictable and may therefore affect overall travel time, and therefore wait times. Environmental conditions that may warrant a slowdown zone include:
  - Limiting speeds within a certain distance of protected marine mammals
  - Adjusting service speeds and vessel design to reduce vessel wakes and potential shoreline erosion, and
  - The presence of shallow water, which may require slow speeds or specialized vessel design to manage operating risk and reduce the effects of propellor wash on sediment or aquatic vegetation
- **Marine traffic that affect speed:** Due to potential interaction with other marine traffic, such as for transportation, shipping, industry, and personal or recreational watercraft, ferries may need to operate at reduced speeds, sometimes unpredictably, for safe operation. This may affect overall travel time and therefore wait times.

- **Sea states and weather conditions that affect speed:** In certain conditions of unpredictable wind or wave action, vessels are required to be designed and equipped to provide a comfortable passenger experience in spite of unideal conditions. This may require a ferry to operate at a reduced speed, or for a vessel to be switched out should special equipment be required for a route condition. For instance, vessels with ice-breaking capabilities may be required where ice is present during winter conditions. This operational need may lengthen overall travel time or delay on-time departure of ferry, therefore affecting wait times.
- **Route length and operating conditions:** At times, a specific route may have certain operating conditions that need to be met. This could require a specific vessel size. For instance, routes with more exposure to wind and wave action may require a larger vessel or an alternative and suitable hull design to maintain safety, reliability, and passenger comfort. At times, these conditions may be unpredictable and require a last-minute change of vessel, creating operational delay and affecting overall travel time as well as wait time.
- **Terminal constraints:** The Coast Guard notes that passenger ferry services and capacity should be coordinated with the capacity of local multimodal connections to avoid local traffic congestion adjacent to the ferry terminal. Vessels should carry appropriate passengers and vehicles such as to avoid a large volume of disembarking vehicles, or vehicles leaving from a park-and-ride lot, that may overwhelm roadways adjacent to the ferry terminal. This regulation affects overall capacity on ferries and therefore will have an impact on wait times.

US Customs and Border Protection[2]: While the agency does put forth regulations in regard to ferry operations, these relate more to baggage and are not foreseen to have an impact on wait times. If however, a new ferry terminal were to be constructed, CBP has certain requirements for terminal facilities. Of particular relevance to wait times is that CBP requires that when planning new ferry terminal facilities, annual port forecasts of projected peak traffic from a five- or ten-year perspective must be used. The construction of a new ferry terminal may affect overall wait times within the ferry system depending on the specific routes served.

State Laws and Standards

Washington Administrative Code3

- **WAC 468-300-700 Preferential loading 9b and 9c:** WSF may vary the amount of vehicle deck space for vehicle reservations as well as deck space dedicated for business, carpool, vanpool, and general reservations depending on factors that include time of day, day of week, season of year, direction of travel, route, vessel size, level of demand, or level of congestion. Depending on the change, it may impact wait time for passengers.

The Washington Administrative Code (WAC) outlines a few specific situations where actual wait time may be affected. However, these conditions do not significantly affect the wait time determination.

> **WAC 468-300-700 Preferential loading 1e:** On routes with reservations, should a vehicle occupant returning from a medical appointment or have been discharged from a hospital and has proof of a medical form certified by a physician that an extended wait would cause detrimental health risks, that vehicle will be offered preferential loading. If a certified medical form is not available, preferential loading will be subject to terminal staff determination.

> **WAC 468-300-700 Preferential loading 1f:** On the Seattle-Bainbridge and Edmonds Kingston ferry routes, should a vehicle occupant claim that an extended wait would cause detrimental health risks to their livestock en-route to veterinary services not otherwise available locally, that vehicle may be allowed preferential loading provided a medical form certified by a veterinarian is available.

Executive Order 20-01: State Efficiency and Environmental Performance[4]: This Executive Order, signed into existence on January 23, 2020, requires that WSF begin the transition of the ferry fleet to a zero-carbon-emission ferry fleet including accelerated adoption of ferry electrification and operational improvements. Overall, the transition to electric ferries and associated overall improvements may have a positive impact on overall wait times within the system.

Policy Considerations for Wait Times

Wait times will be affected by specific policy decisions by WSF regarding targeted level of demand, the number of routes and service types required, and the desired level of service (LOS) for customers. The below WSF policies will directly affect operations and therefore wait times.

- Targeted level of demand, peak volumes of passengers and vehicles;
- Route and service types;
- Desired LOS;
- Considerations by mode: passenger vehicle, commercial vehicle;
- Recruitment and training;
- Reliability in regard to vessel maintenance, relief vessels, and replacing retiring vessels;
- Seasonal sailing schedule planning considerations (vessel capacity and availability, contracting, crewing, training needs);
- Electrification and alternative fuels
- Terminal planning and capacity considerations
- Energy storage
- Integration with local utility grid
- Shore-vessel charging connection
- Customer information and service disruption communications including modes of communication;
- Reducing greenhouse gas emissions;
- Automated vehicle queue detection technology and capabilities; and
- Adaptive management strategies that spread out peak demand and minimize wait times.

Given WSF policy, the following challenges that may present themselves have a direct impact on wait times during real-time operations.

- Crew relief requests
- Unplanned service disruptions
- Special events