Oregon Statewide ITS Architecture and Operational Concept Plan

Prepared for

Oregon Department of Transportation

Prepared by

DKS Associates
TRANSPORTATION SOLUTIONS

ACKNOWLEDGMENTS

(See Appendix Q for acknowledgments for previous versions of the plan)

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REVISION HISTORY

Version	Date	Description	Author
1	August 2006	Although the Statewide ITS Architecture was originally created by ODOT in Turbo Architecture in 2000, the first documentation of the Oregon Statewide ITS Architecture (including the development of operational concepts) was completed in 2006.	DKS Associates
2	December 2010	Major revisions: • Updated the Oregon Statewide ITS Architecture from Turbo Version 3.1 to 5.0 and from National ITS Architecture Version 5.1 to 6.1. • Reviewed and updated the architecture and operational concepts to reflect projects implemented since 2006. • Developed a public transportation operational concept and updated the architecture to include full coverage of public transportation in Oregon. • Added a project sequencing matrix for 2011 to 2021.	DKS Associates
3	May 2011	Developed an operational concept for road user charging and updated the Oregon Statewide ITS Architecture to include road user charging.	DKS Associates and D'Artagnan Consulting
4	January 2017	Developed a connected and automated vehicle operational concept based on the CVRIA and developed associated project-specific ITS architectures for case studies using SET-IT. Updated the project sequencing matrix to cover the funding bienniums from 2015 through 2021. _____ Note: Although FHWA updated the National ITS Architecture in 2012 (Version 7.0) and 2015 (Version 7.1), FHWA is planning major updates to the National ITS Architecture and Turbo Architecture in 2017. Therefore, ODOT plans to update the entire Oregon Statewide ITS Architecture after those updates have been made. All discussions of the National ITS Architecture and the Oregon Statewide ITS Architecture in this plan are based on Version 6.1 of the National ITS Architecture.	DKS Associates
5	September 2022	Updated information related to central traffic signal systems and regional ITS plans	DKS Associates

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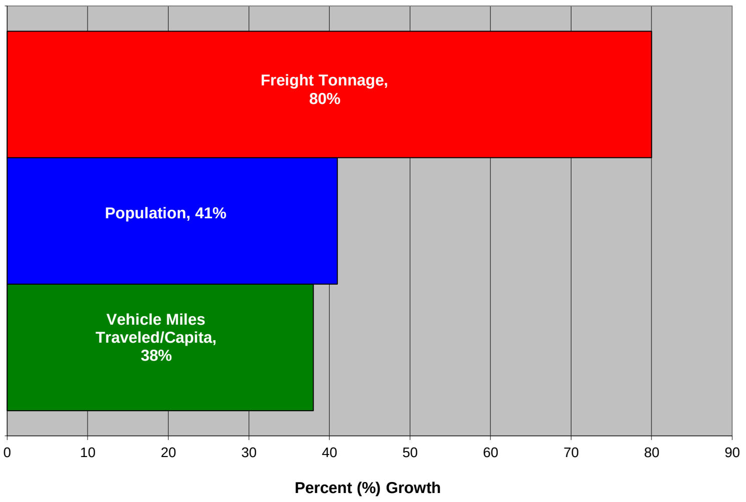
INTRODUCTION

The objective of this report is to document the Oregon Statewide Intelligent Transportation System (ITS) Architecture, which was originally created in 1998. The Oregon Department of Transportation (ODOT) and the Federal Highway Administration (FHWA) collectively developed this plan and the outcome is a long-term phased deployment of ITS projects, which include advanced technologies and management techniques, aimed to improve the safety, efficiency, and sustainability of the transportation system. This effort plays a key role in guiding institutional agreement and technical integration for ITS project deployment throughout the state to ensure that ITS strategies are complementary from region to region.

The Problem

2006 - 2030 Forecasted Trends

(Source: *Oregon*



Increasing traffic congestion, due to capacity constraints and incidents, affects the mobility of travelers and freight throughout Oregon. Congestion results in travel delay, reduced productivity, and a frustrated driving public. According to the *2000 Census*, the population of Oregon grew 20 percent from 1990 to 2000 and most of the state's metropolitan areas grew at a much higher rate than the state for that same time period. ODOT forecasts that the state's population will grow 41 percent from 2006 to 2030 and freight tonnage will increase by 80 percent[1]. They also expect a 1.35 percent annual increase in vehicle miles traveled (VMT) per capita through 2030. The expected growth in population, freight tonnage, and VMT will place an enormous burden on the existing transportation infrastructure.
As the state grows, public agencies must realize that high land and construction costs and environmental constraints make it difficult to build new transportation infrastructure as the single means of relieving congestion. Therefore, a systematic approach is necessary to effectively manage the state's transportation system and capitalize on the existing infrastructure as the state grows. This includes a combination of intelligent transportation systems in conjunction with new roadway construction when applicable.

The Opportunity

ITS applications offer a significant opportunity to improve the efficiency and safety of the surface transportation system in Oregon. These applications help improve transportation system operations by performing a function more quickly or reliably or by providing a service that was not previously available. As a result, ITS helps improve the mobility of people and goods on the existing roadway infrastructure and also offers the potential for substantial savings on future construction, particularly of highways. Often, the importance of investing in operations is easily

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[1] *Oregon Transportation Plan, July 19, 2006 Public Hearing Draft*. Oregon Department of Transportation, Planning Section, Transportation Development Division, June 29, 2006.

overlooked, but is necessary to ensure that the traveling public makes safe, efficient, and sustainable use of existing roadways.

What is ITS?

Intelligent transportation systems (ITS) involve the application of advanced technologies and proven management techniques to relieve congestion, enhance safety, provide services to travelers, and assist transportation system operators in implementing suitable traffic management strategies. ITS focuses on increasing the efficiency of existing transportation infrastructure, which enhances the overall system performance and reduces the need to add capacity (e.g., travel lanes). Efficiency is achieved by providing services and information to travelers so they can (and will) make better travel decisions and to transportation system operators so they can better manage the system. ITS technologies are used by ODOT and many other agencies throughout Oregon today and plans are in place to expand the use of ITS applications in the future.

ITS and TSMO

ITS is a key component of and complement to ODOT’s approach to transportation systems management and operations (TSMO). TSMO represents a philosophical shift in how agencies manage their transportation systems in recognition of the limits of traditional roadway capacity expansion for managing congestion and operations. It employs performance-based traffic management practices, often enabled by ITS, and coordinated across multiple jurisdictions, agencies, and modes to maintain or even restore performance of the existing transportation system before extra capacity is needed. TSMO strategies are supported by both FHWA and AASHTO.

ODOT has established transportation goals that are both supportive of and supported by TSMO. The overarching goal of the 2006 Oregon Transportation Plan (OTP) is “a safe, efficient and sustainable transportation system that enhances Oregon’s quality of life and economic vitality.” OTP Goal 2, Management of the System, is specific to TSMO and states “improve efficiency of the transportation system by optimizing the existing infrastructure with improved operations and management.” OTP Key Initiatives A and B reflect the desired direction of the OTP to maximize existing system assets and to optimize capacity using TSMO strategies.

Although connected and automated vehicle (CAV) technologies have been part of the national ITS conversation for many years, these technologies are now maturing at a rapid pace. Connected vehicles are those able to send data to and/or receive data from their environments while in operation. Automated vehicles are vehicles in which at least some portion of the vehicle’s control operates without driver input. ODOT recognizes that CAV technologies can provide improvements in safety, mobility, and environmental impacts and may increase the efficiency of agency operations; therefore, they are preparing for CAV technologies. Prior to embarking on a series of CAV pilot projects in Oregon, this plan was updated in 2016 to include a statewide connected and automated vehicle operational concept and ITS architectures for initial case studies in 2022, ODOT developed the framework for a statewide Connected Vehicle Ecosystem, a scalable CV data exchange platform to support CV-based safety and mobility applications and gather and distribute CV data.

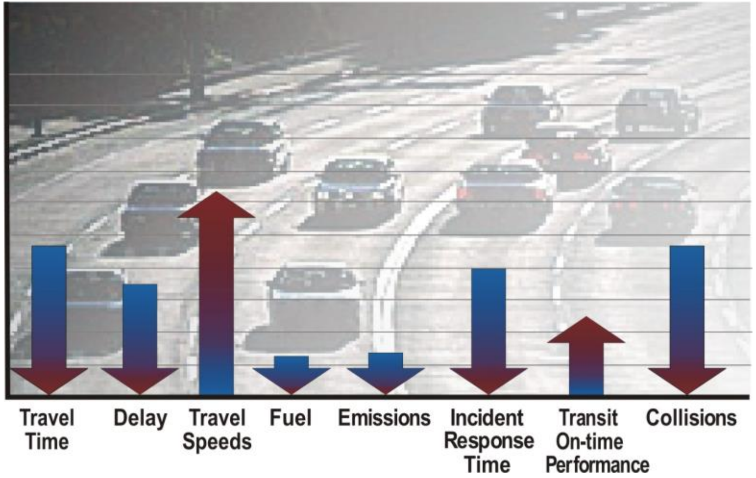
Why Develop an ITS Architecture?

An ITS architecture provides a framework of policies, procedures, and strategies for integration of the state’s existing resources to effectively meet future statewide transportation needs and expectations. The following reasons provide the basis for developing a statewide ITS architecture for Oregon:

- Oregon cannot build itself out of congestion.
- Oregon endeavors to maximize the efficiencies and improve the safety of the existing infrastructure.
- The public demands better information about transportation system conditions and mobility options.
- The architecture fosters multi-agency coordination for system operations.
- The architecture can be used during project development to assist with the project concept of operations, high-level and detailed requirements, design components, and specifications.
- The Federal Highway Administration requires that all ITS projects funded through the Highway Trust Fund shall be in conformance with the National ITS Architecture and applicable standards.

What are the Expected Benefits?

ITS are aimed at improving the safety and operational efficiency of the existing transportation infrastructure by reducing vehicle delays related to recurrent and non-recurrent congestion, reducing crashes and incident response times, and providing travelers with real-time information to make informed route and mode choice decisions. Quantifiable benefits resulting from ITS include:



- Reduced vehicle delays
- Reduced crashes
- Improved air quality
- Reduced fuel consumption
- Improved travel times

Other accrued benefits, which are more difficult to quantify, include reduced driver frustration and reduced driver anxiety from having real-time travel information. Additionally, improved efficiency due to coordinated and cooperative agency actions can produce long-term savings, particularly in relation to coordinating statewide and regional projects and a coordinated response to incidents. ITS deployments around the state of Oregon have yielded many of these; some of these are highlighted herein.

Traveler Information

The dissemination of real-time traveler information provides travelers the ability to make informed travel choices, which could include changing a route, or selecting an alternate mode of travel. The resulting benefits include:

- 7- to 12-percent reduction in travel time
- Up to 33-percent reduction in emissions

Incident Management

ODOT, in association with the Oregon State Police, currently operates an incident management program in Region 2 to assist disabled vehicles. The incident management program includes incident response vehicles that patrol the Region 2 roadways to assist motorists and reduce the duration of incidents and reduce the resulting traffic congestion. Based on an evaluation of the program, the following benefits have been identified:

- 15-percent reduction in average incident duration
- 35-percent reduction in vehicle-hours of incident delay

Coordinated Traffic Signal Timings

State-of-the-art traffic signal systems, with communication to a central server and software and coordinated signal timing plans have proven to produce substantial benefits to the public. Examples from local coordinated signal timing projects in Oregon have produced the following benefits:

- 10- to 40-percent reduction in stops
- 15- to 45-percent reduction in delay
- 5- to 25-percent reduction in travel time
- Up to 15-percent reduction in fuel consumption

ITS Vision and Goals in Oregon

“The vision of ITS in Oregon is to adopt systems, technologies and partnerships that enhance mobility, transportation efficiency, safety, productivity and to promote economic prosperity and livability. The goals of implementing ITS in Oregon are to:

- Improve productivity of the transportation system users;
- Improve safety;
- Improve efficiency of the transportation system;
- Improve mobility and accessibility;
- Improve intermodal connections;
- Promote environmental responsibility and reduce energy use;
- Promote economic development in Oregon;
- Utilize technology as an asset of the transportation system.”[2]

The ITS vision and goals support the five underlying fundamental themes of the *Oregon Transportation Plan*, which include: (1) accessibility and mobility, (2) economic development, (3) equity, (4) safety, and (5) sustainability.[3]

Report Elements

The Statewide Architecture Committee, which consisted of key members of the ODOT ITS Unit and FWHA, guided this project with additional input from expanded stakeholders. A key component of updating the Oregon Statewide ITS Architecture in 2010 included the development of an operational concept plan that provides an overview of how Oregon’s stakeholders and systems work together to provide ITS services. This report documents the following elements:

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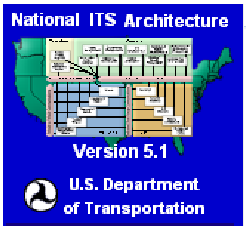
[2] *Oregon ITS Strategic Plan: 1997-2017, Executive Report*. Oregon Department of Transportation, 1998.

[3] *Oregon Transportation Plan, July 19, 2006 Public Hearing Draft*. Oregon Department of Transportation, Planning Section, Transportation Development Division, June 29, 2006.

- Overview of the National ITS Architecture
- Systems engineering
- Geographic boundary, timeframe, and scope of the Oregon Statewide ITS Architecture
- ITS stakeholders within the state
- Inventory of existing and planned systems
- User services needed in the state
- Market packages that address user services
- Interconnects between systems
- Operational concept plan
- ITS standards
- Project sequencing
- Maintenance plan
- Future considerations

Appendix A includes a glossary of the acronyms used throughout this report.

NATIONAL ITS ARCHITECTURE OVERVIEW



The U.S. Department of Transportation developed the National ITS Architecture to ensure that intelligent transportation systems deployed around the country can communicate with one another and share information to maximize the return of investment on ITS. "The National ITS Architecture is a general framework for planning, defining, and integrating ITS. It was developed to support ITS implementations over a 20-year time period in urban, interurban, and rural environments across the country."[4] The National ITS Architecture, currently Version 7.1, is fully documented online[5]. The version number is updated when a number of changes or additions are made to the architecture.

For example, if a transportation agency wants to clear incidents faster, the architecture defines a function to monitor roadways and identifies the interconnection and information flows between the roadway, the traffic operations center, and the emergency management center needed to provide responders with incident information. The architecture provides the framework for the process, but does not define how this is done with technology or management techniques.

The Federal Highway Administration (FHWA) published a Final Rule policy[6] that all agencies seeking federal highway trust funding for ITS projects must develop a regional or statewide architecture that is compliant with the National ITS Architecture. The Federal Transit Administration (FTA) published a similar policy[7] that applies to federal funding from the mass transit account of the highway trust fund.

In summary, the primary reasons for developing a statewide ITS architecture that conforms with the National ITS Architecture include the following:

- Develop a framework for institutional agreements and technical integration for organized ITS project deployment that meets local transportation user needs.
- Build consensus among stakeholders about resource and information sharing and activity coordination.
- Meet federal funding requirements.

Major updates to the Oregon Statewide ITS Architecture were last made in 2010 to reflect Version 6.1 of the National ITS Architecture. The focus of the 2016 update to this document was the addition of a connected and automated vehicle operational concept. In 2014, FHWA published the Connected Vehicle Reference Implementation Architecture (CVRIA) and has since made updates through Version 2.2[8]. The CVRIA provides physical, functional, communications, and enterprise viewpoints based on numerous CAV developments and

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[4] *Regional ITS Architecture Guidance: Developing, Using, and Maintaining an ITS Architecture for Your Region*. Report FHWA-OP-02-024. U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, National ITS Architecture Team, Oct. 12, 2001.

[5] *National ITS Architecture Version 7.1*. Developed by Iteris Inc. for the U.S. Department of Transportation, April 2015. http://itsarch.iteris.com/itsarch/.

[6] *Intelligent Transportation System Architecture and Standards: Final Rule*. FHWA Docket No. FHWA-99-5899. U.S. Department of Transportation, Federal Highway Administration, Jan. 8, 2001.

[7] *Federal Transit Administration National ITS Architecture Policy on Transit Projects: Notice*. FTA Docket No. FTA-99-6147. Federal Transit Administration, Jan. 8, 2001.

[8] *Connected Vehicle Reference Implementation Architecture Version 2.2*. Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation. Last updated July 7, 2016. https://www.iteris.com/cvria/index.html.

research projects. It provides the basis for a common language definition and early deployment concepts that will ultimately be integrated into the National ITS Architecture. Although CVRIA is separate from the National ITS Architecture, Version 7.1 of the National ITS Architecture included linkages to CVRIA.

Since FHWA is planning major updates to the National ITS Architecture in 2017, revisions to the Oregon Statewide ITS Architecture have been deferred until those changes are complete. All National ITS Architecture and Oregon Statewide ITS Architecture discussions and terminology in this plan are based on Version 6.1 unless otherwise noted.

The National ITS Architecture is comprised of two components: the logical architecture and the physical architecture. The following subsections provide a brief overview of these concepts.

Logical Architecture

The logical architecture defines the requirements needed to provide the selected user services. User services describe what functions ITS should perform from the user's perspective. The logical architecture is comprised of the following components:

- Processes: Activities and functions that must work together and share information to provide a user service.
- Terminators: Represent the people, systems, environment, and other subsystems that interact with intelligent transportation systems. These are described in more detail in the Physical Architecture subsection.
- Data Flows: Information exchange between processes or between processes and terminators. For example, light rail train arrival data is exchanged between wayside detectors in the tracks and traffic signal systems.
- Data Stores: Repositories of information maintained by the processes.

The logical architecture is typically described by data flow diagrams (DFDs) and process specifications (PSpecs) for specific project-related systems. Data flow diagrams graphically represent the processes, terminators, data flows, and data stores in a hierarchical format. The process specifications are used to write the specifications for specific project-related systems and consist of an overview, a set of functional requirements, and a complete listing of inputs and outputs. Public sector agencies tailor the logical architecture by identifying the processes, terminators, data flows and data stores that are existing or planned for a region.

Physical Architecture

The physical architecture creates a high-level structure around the processes and data flows included in the logical architecture. It consists of subsystems, equipment packages, terminators, architecture flows, and architecture interconnects, which are all described in this subsection. Figure 1 illustrates the high-level physical architecture of the National ITS Architecture and includes the subsystems and architecture interconnects between subsystems.

Figure 2 depicts the interaction between the logical and physical architectures.

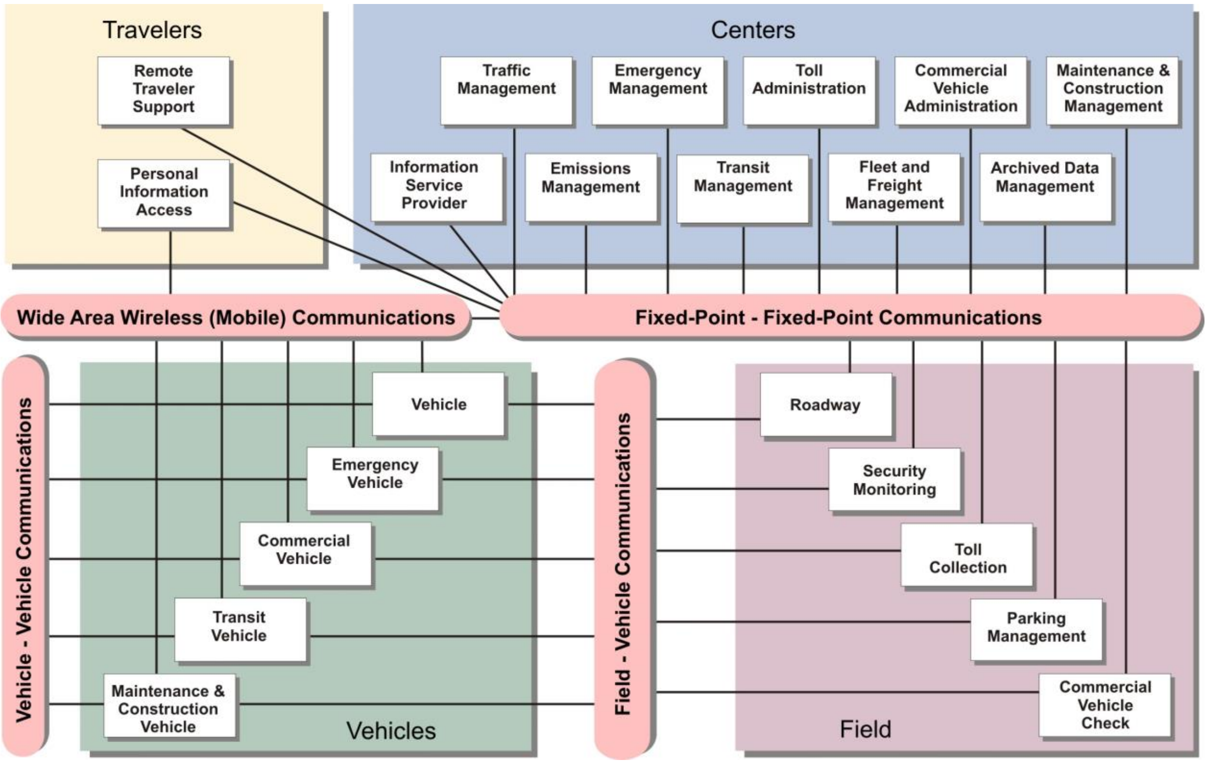

Figure 1. High-Level Physical National ITS Architecture

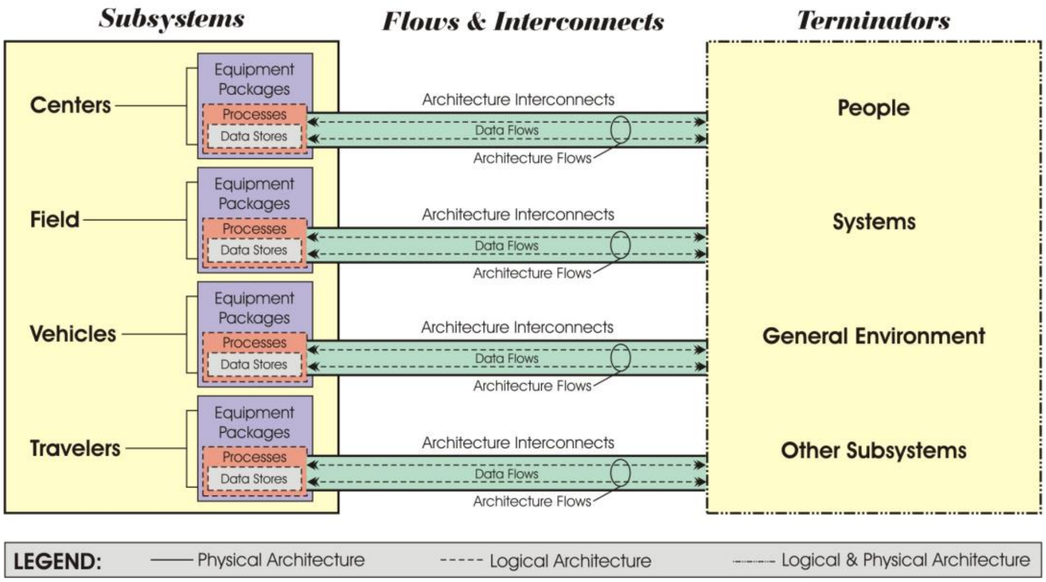

Figure 2. Logical and Physical Architecture Components

Subsystems

A subsystem represents a grouping of processes defined in the logical architecture that may be defined by single entities. There are 22 subsystems in the physical architecture that are assigned to four overarching classes that correspond to the physical world as described in Table 1 and illustrated in Figure 1.

Table 1. Subsystem Classes

Subsystem Class	Function	Real World Examples
Centers	Provide management, administration, and support functions for the transportation system.	▪ ODOT Regional TOCs ▪ 911 Centers ▪ Oregon State Police Dispatch Centers
Field	Provide direct interface to the roadway network, vehicles traveling on the roadway network, and travelers in transit.	▪ Traffic Signals ▪ Dynamic Message Signs ▪ Weather Warning Systems
Vehicles	Use the roadway network and provide safety systems and driver information.	▪ Incident Response Vehicles ▪ Law Enforcement and Fire Vehicles
Travelers	Gain access to traveler information through the use of equipment.	▪ TripCheck Website ▪ Smart Phones

Equipment Packages

Equipment packages group similar processes of a subsystem together into a package that can be implemented to address user services. The equipment packages are considered the building blocks of the physical architecture subsystems. Table 2 lists several examples of equipment packages in the National ITS Architecture.

Table 2. Sample Equipment Packages

Equipment Package	Process Specifications (PSpecs)	User Service Addressed
Roadway Basic Surveillance	▪ Process Traffic Sensor Data ▪ Process Traffic Images	Traffic Control
Mayday Support	▪ Determine Coordinated Response Plan ▪ Communicate Emergency Status ▪ Process Mayday Messages ▪ Provide Operator Interface for Emergency Data	Emergency Notification and Personal Security
Traffic and Roadside Data Archival	▪ Manage Roadside Data Collection	Information Management

Terminators

Terminators, also called entities, define the boundary of the architecture by representing the people, systems, other subsystems, and general environment that interface with intelligent transportation systems. The National ITS Architecture includes interfaces between terminators and subsystems and processes, but does not allocate function requirements to terminators. For example, an emergency system operator is a terminator that interfaces with the emergency management subsystem; however, the architecture does not define the functions performed by the operator to support the agency. The same set of terminators applies to both the logical and physical architectures, but the logical architecture processes communicate using data flows and the physical architecture subsystems communicate using architecture flows.

Architecture Flows

Architecture flows, also called information flows, are groupings of data flows that represent the actual information exchanged between subsystems and terminators and are the primary tool used to define interfaces within an ITS architecture. For example, an accident report is an architecture flow that is exchanged between a 911 center (subsystem) and the appropriate emergency system operator (terminator).

Architecture Interconnects

Architecture interconnects, also called information interconnects, are the communications paths that carry architecture flows between the subsystems and terminators. These interconnects, shown in Figure 1, are typically grouped into one of the four categories listed in Table 3.

Table 3. Architecture Interconnects

Interconnect	Function	Real World Example
Fixed-Point to Fixed-Point Communications	Uses a communications network to link stationary entities.	▪ Fiber optic connection between a traffic operations center and a CCTV camera
Wide Area Wireless Communications	Uses wireless devices to link users and infrastructure-based systems.	▪ Mobile telephone used to access traveler information
Dedicated Short Range Communications	Uses wireless communications channels to link vehicles and the immediate infrastructure within close proximity.	▪ Radio communications between the roadside and a vehicle
Vehicle to Vehicle Communications	Uses a wireless system to link communications between vehicles.	▪ Future vehicle collision avoidance systems

SYSTEMS ENGINEERING

"Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem: operations, performance, test, manufacturing, cost and schedule, training and support, and disposal."[9] In addition to having a statewide or regional ITS architecture in place, FHWA also requires a systems engineering analysis commensurate with the project scope for all ITS projects that use federal funds. At a minimum FHWA requires the following elements as part of the systems engineering analysis:

- Identification of portions of the statewide architecture being implemented
- Identification of participating agencies with roles and responsibilities
- Definition of requirements
- Analysis of alternatives
- Procurement options
- Standards and testing procedures
- Resources for operations and maintenance

Figure 3 depicts the lifecycle of project development using a systems engineering approach. The main benefits of following this approach include a final product/system that meets all of the user needs, cost and schedule control, and risk reduction. ODOT uses a systems engineering approach on all their major ITS projects that exceeds the FHWA minimum requirements.

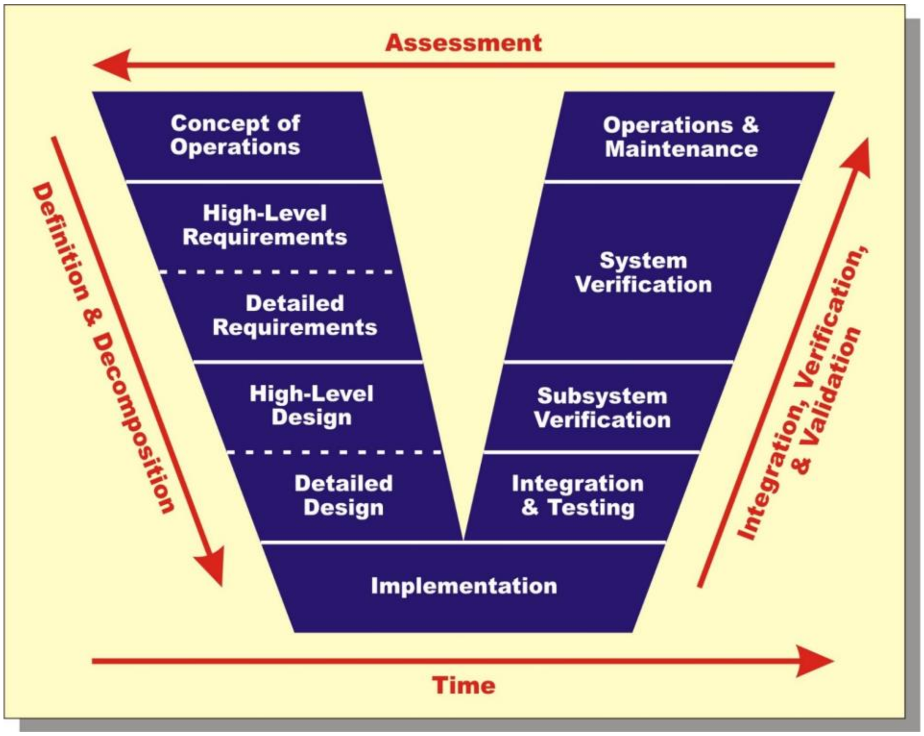

Figure 3. Systems Engineering Lifecycle

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[9] *What is Systems Engineering?* International Council on Systems Engineering, June 14, 2004. http://www.incose.org/practice/whatissystemseng.aspx. Accessed Aug. 16, 2006.

OREGON STATEWIDE ITS ARCHITECTURE

The Oregon Statewide ITS Architecture was originally developed in 1998 to guide the deployment of ITS applications in Oregon over a 20-year period and to meet federal funding requirements. It was later input into Turbo Architecture[10], which is a software tool designed to support development of statewide, regional, and project architectures based on the National ITS Architecture. The Turbo Architecture database is intended to be a living document that gets updated by the key stakeholders as the statewide needs change. The Turbo Architecture software is updated concurrently with National ITS Architecture updates and was first developed in conjunction with Version 3.0 of the National ITS Architecture.

CVRIA was developed in 2014 as a framework for early CAV deployments with the goal that it will ultimately be integrated into the National ITS Architecture. Version 7.1 of the National ITS Architecture included linkages to CVRIA. A tool called Systems Engineering Tool for Intelligent Transportation (SET-IT) was developed to integrate drawing and database tools with CVRIA so that users can develop project architectures for CAV pilots, test beds, and early deployments.

Table 4 provides development timelines for the National ITS Architecture, Turbo Architecture software, CVRIA, SET-IT software, and the Oregon Statewide ITS Architecture. Starting in 2012, the Turbo Architecture version numbers align with the National ITS Architecture version numbers. The CVRIA and SET-IT version numbering have been in alignment since the start.

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[10] *Turbo Architecture*. Developed by Iteris, Inc. for the U.S. Department of Transportation, Federal Highway Administration. http://www.iteris.com/itsarch/html/turbo/turbomain.htm

Table 4. ITS Architecture Timelines

Year	National ITS Architecture	Turbo Architecture	Connected Vehicle Reference Implementation Architecture & SET-IT	Oregon Statewide Architecture
1996	Version 1.0			
1997				
1998	Version 2.0			Strategic Plan
1999	Version 3.0			
2000		Version 1.0		Turbo Database
2001		Version 1.1		
2002	Version 4.0	Version 2.0		
2003	Version 5.0			
2004		Version 3.0		
2005	Version 5.1	Version 3.1		
2006				Versions 2006-1 and 2006-2
2007	Version 6.0	Version 4.0		
2008				
2009	Version 6.1	Version 4.1		
2010		Version 5.0		Version 2010-1
2011				Version 2011-1
2012	Version 7.0	Version 7.0[A]		
2013				
2014			Version 1.0	
2015	Version 7.1	Version 7.1	Version 2.0	
2016			Version 2.2	B

A. The Turbo Architecture version numbering skipped Version 6.0 in order to align with the version numbering of the National ITS Architecture.

B. Project-specific ITS architectures for CAV case studies were developed in 2016 using SET-IT in a separate environment from the Oregon Statewide ITS Architecture Turbo database.

Oregon ITS Plans

In addition to a statewide ITS plan, a number of regional ITS plans have been developed throughout Oregon as shown in Table 5. These plans provide the institutional agreement and technical integration framework within each of these regions whereas the statewide ITS plan provides the framework for systems used throughout Oregon that tie together each of the regions. For example, a regional ITS plan may contain detailed elements about a local transit system whereas the statewide ITS plan includes a system for disseminating transit traveler information throughout the state for all local transit systems.

Six of the larger metropolitan areas (Salem-Keizer, Central Willamette Valley, Eugene-Springfield, Rogue Valley, Deschutes County, and Klamath County) used a multi-agency approach to develop a single ITS plan for the metropolitan region and in some cases surrounding rural areas. These plans were guided by consensus from key stakeholders from transportation, transit, and emergency management agencies as well as other expanded stakeholders and include, at a minimum, a regional architecture, operational concept, and phased long-term deployment plan.

Table 5. Oregon Statewide and Regional ITS Plans

ITS Plan	Completion Date	Plan Timeframe	Notes
STATEWIDE			
Oregon ITS Strategic Plan: 1997 – 2017	Oct. 1998	20-year	
REGIONAL			
Deschutes County ITS Plan	March 2005	20-year	Updated April 2020
Regional ITS Operations & Implementation Plan for the Eugene-Springfield Metropolitan Area	Nov. 2003	20-year	Updated November 2021
Regional ITS Operations & Implementation Plan for the Greater Rogue Valley	July 2004	20-year	Update underway for January 2017
Salem-Keizer Metropolitan Area ITS Plan	Aug. 2005	20-year	
Central Willamette Valley ITS Plan	Dec. 2010	20-year	
Klamath County ITS Plan	July 2016	10-year	
Lower John Day ITS Plan	Oct. 2021	10-year	
PORTLAND METROPOLITAN AREA			
Clackamas County ITS Plan	Feb. 2003	20-year	Updated April 2021
Gresham/East Multnomah County Traffic Signal System and Communications Master Plan Update	Sept. 2001	10-year	
City of Portland Intelligent Transportation System Implementation Plan	June 1997	20-year	
ODOT Region 1, Intelligent Transportation System Plan	April 2000	5-year	Updated January 2014
	July 2005	5-year	
Portland International Airport Intelligent Transportation Systems Master Plan	Feb. 2002	10-year	
Regional ITS Architecture and Operational Concept Plan for the Portland Metropolitan Area	Oct. 2005	10-year	Update underway for January 2017
TriMet 5-Year Intelligent Transportation System Plan	2001	5-year	
Washington County ITS Plan	Feb. 2005	5-year	Updated December 2020

The statewide plan and each of the regional plans includes an architecture. The *Regional ITS Architecture and Operational Concept Plan for the Portland Metropolitan Area* includes one architecture that encompasses all of the Portland metropolitan area ITS plans.

The Portland metropolitan area has taken a slightly different approach due to its large size and complexity. A number of agencies within the Portland metropolitan area have developed ITS plans specific to their agency or group of agencies/stakeholders as listed in Table 5. Each ITS plan varies in scope and timeframe, but all of the plans combined cover the geographic area of Portland and include some form of project sequencing. All of these ITS plans share one common regional architecture and operational concept plan, which is documented in the *Regional ITS Architecture and Operational Concept Plan for the Portland Metropolitan Area.*

Architecture Update Process

The most recent update to the Oregon Statewide ITS Architecture was completed in 2010 and was driven by: two updates to the National ITS Architecture since 2006, the need to expand the public transportation service area; and the need to capture the ITS projects implemented since 2006 and planned for the next 10 years. Appendix B includes a summary of the changes to the National ITS Architecture between Versions 5.1 and 6.1 that impact the Oregon Statewide ITS Architecture. A current evaluation of the FWHA Regional ITS Architecture Assessment Checklist for the newly updated architecture can be found in Appendix C.

Figure 4 illustrates the steps that were followed to update the Oregon Statewide ITS Architecture. The Statewide Architecture Committee provided input throughout the architecture update process to obtain consensus. Additionally the public transportation service area was developed under the guidance of the Public Transportation Advisory Committee (PTAC). Each of the following steps is described in this section of the report:

- Stakeholders: The stakeholder list was updated in Turbo Architecture.
- System Inventory: Existing and planned ITS elements were updated in Turbo Architecture.
- User Services: The user services in use or planned for use were documented.
- Market Packages: The market packages were updated in Turbo Architecture based on updates to the system inventory and user services. New market packages added to the National ITS Architecture since 2006 were also selected.
- Interconnect and Information Flows: Information flows between subsystems were updated in Turbo Architecture to reflect changes to the aforementioned architecture changes.

Appendix D includes a 2010 summary report from Turbo Architecture that includes a description of the statewide architecture, geographic boundary, timeframe, scope, and general revision and change log information. Appendix E includes an attribute change log that summarizes the changes to the statewide architecture attributes in 2010. Since Turbo Architecture does not generate any type of change log other than basic information (e.g. date of database maintenance, brief description), change log spreadsheets were created to document the changes to the stakeholder list, system inventory, and market packages and these are referenced throughout this section. A change log was not generated for the changes to the interconnects and information flows due to the large number of flows contained within the Oregon Statewide ITS Architecture.

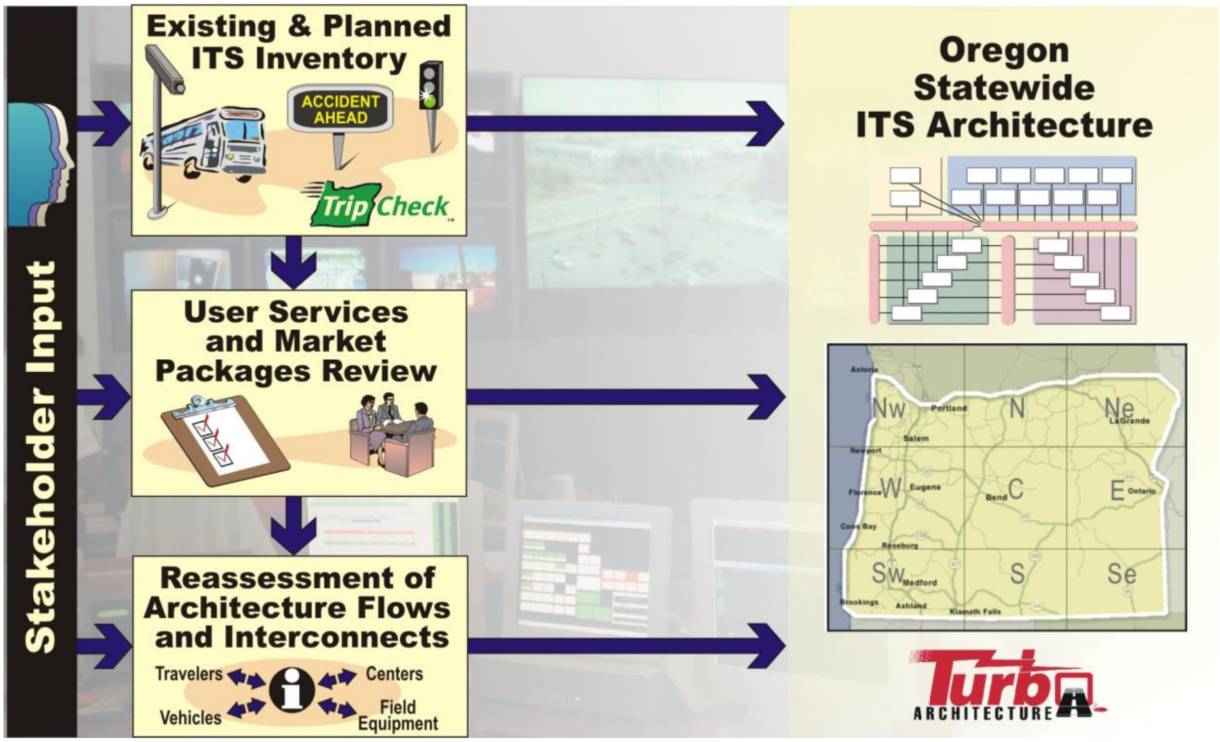


Figure 4. Oregon Statewide ITS Architecture Update Process

Status Field in Turbo Architecture

Turbo Architecture allows the user to customize the status settings. The following status settings have been incorporated in the Turbo Architecture database for the Oregon Statewide ITS Architecture:

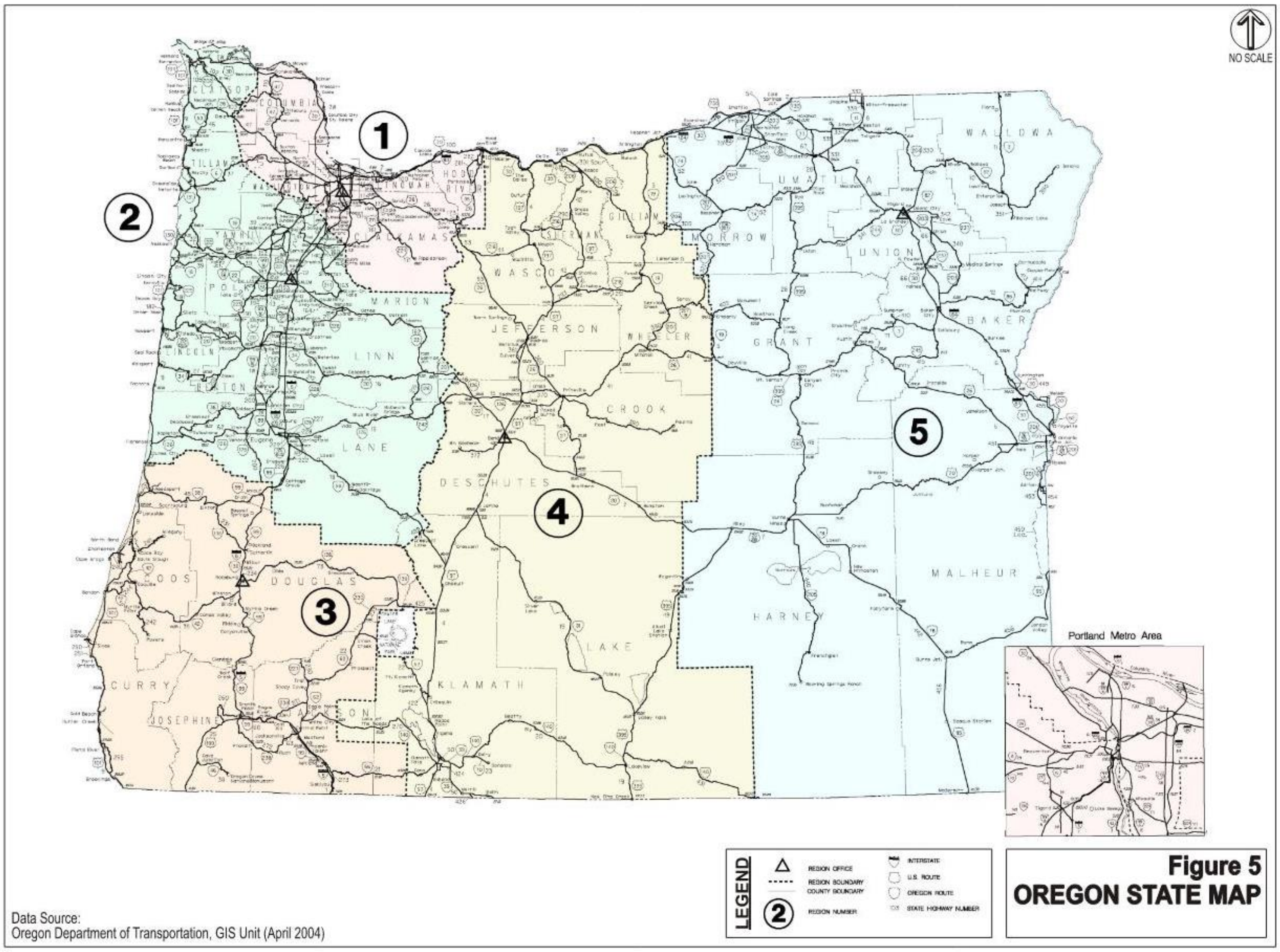
- Existing: Items that currently exist.
- Programmed: Items that are currently underway/under design or that have funding secured for deployment in the near future.
- Planned: Items that are included in statewide plans but do not yet have funding.
- Future: Items that may occur within the architecture timeframe but are not included in any current statewide plans and do not yet have funding.
- Not Planned: Items not currently planned for the state within the architecture timeframe.

These status fields were incorporated in the 2006 update to the Oregon Statewide ITS Architecture; however, in the 2010 update the status fields for all new elements, market packages, and flows were limited to: existing, existing/planned, planned, and not planned. Funding commitments constantly change, which makes it hard to track programmed funds. Future ITS projects that may happen later in the 10-year timeframe can be added during subsequent updates when more details are available to capture those types of projects in the architecture.

Geographic Boundary

The geographic boundary of the Oregon Statewide ITS Architecture is the state of Oregon, which includes 36 counties and approximately 240 cities. ODOT has designated five discrete regions within the state for the practical purpose of overseeing their transportation infrastructure in more manageable pieces.

Figure 5 includes a map of Oregon that depicts cities, counties, and ODOT's five regions. ODOT has also divided the state into 15 maintenance districts to support daily maintenance operations. Although the architecture is defined by the ITS components within the state border, there are stakeholders, inventory elements, and information flows in the architecture that capture the cross-jurisdictional interfaces with Oregon's neighboring states (Washington, Idaho, Nevada, and California).



Data Source:
Oregon Department of Transportation, GIS Unit (April 2004)

Figure 5. Oregon State Map

Timeframe

The 2010 update to the Oregon Statewide ITS Architecture spans a 10-year timeframe from Years 2011 - 2021. The original strategic plan covered the 20-year period from Years 1997 – 2017 and the timeframe in the Turbo Architecture database was previously undefined. A 10-year timeframe best suits the state's needs and the fluid nature of technology advancements and changes.

Scope

The 2010 scope of the Oregon Statewide ITS Architecture includes the following ITS service areas:

- Transportation Operations Centers
- Regional Traffic Control
- Traveler Information
- Maintenance and Construction Operations
- Road Weather Operations
- Incident Management
- Emergency Management
- Archived Data Management
- Commercial Vehicle Operations
- Public Transportation (added in 2010)
- Road User Charging (added in 2011)

The transportation and emergency management agencies within Oregon currently perform these key services on a day-to-day basis.

In 2010 the Steering Committee chose not to include the Advanced Vehicle Safety Systems service area for various reasons. Although important, this service area was a higher priority for the automotive industry at that time than for public agencies. A connected and automated vehicle service area was developed in 2016 as a companion to the Oregon Statewide ITS Architecture using SET-IT since Turbo Architecture does not include the CVRIA architecture.

Project Architectures

The Turbo Architecture software also allows the inclusion of project architectures within the statewide architecture for major projects. The Statewide Architecture Committee decided to include the following four project architectures:

- Transportation Operations Center System (TOCS)
- TripCheck System
- TripCheck Traveler Information Portal (TTIP)
- Road Weather Operations

These statewide projects are large in scope and involve the integration of a considerable portion of the Oregon Statewide ITS Architecture. In particular, these projects capture the principle existing or planned systems used by ODOT on a day-to-day basis in each of their five regions. These project architectures also provide an interface to ODOT and local agency elements included in the regional architectures. For example, ODOT uses the TripCheck system for distribution of traveler information statewide and one of the functions of TTIP is to pass traveler information from local agencies to the TripCheck system. The Oregon Statewide ITS Architecture captures traveler information flows from ODOT to the TripCheck system and from a generic local agency stakeholder to TTIP and from TTIP to the TripCheck system. The regional architectures describe the particular traveler information flows to TTIP from the numerous local agency systems within the region.

The Turbo Architecture software enables the user to select inventory elements and services within the statewide architecture that apply to a specific project. It also provides the user a way to filter the statewide architecture by project to assist with project development, systems engineering analysis, and project implementation. The 2010 Turbo Architecture summary report included in Appendix D also includes details, such as general description and scope, for each project architecture and Appendix E includes a change log of how these attributes have been updated.

Stakeholders

Stakeholders are the backbone of the Oregon Statewide ITS Architecture and consensus amongst stakeholders has helped the state successfully deploy ITS projects in the past and will continue to ensure coordination and integration of future ITS endeavors. The key stakeholders include the transportation, transit, and public safety agencies who primarily own and operate ITS throughout the state. Expanded stakeholders include other public agencies, private sector organizations, and travelers/system users.

Appendix F contains the 2010 Turbo Architecture report of the complete list of the stakeholders/ stakeholder groups and Appendix G includes a detailed change log of all the changes made to the stakeholder list.

System Inventory

The Oregon Statewide ITS Architecture includes a comprehensive inventory of the existing and planned ITS elements in Oregon. In Turbo Architecture each inventory element includes the element name, the associated stakeholder, and the associated subsystem(s) and/or terminator(s). There is also a field available for including a description. The Oregon Statewide ITS Architecture primarily focuses on the elements that comprise the subsystems, but does include a few key terminators. Terminators typically play a larger role in project-specific architectures (e.g. the personnel that operate the actual subsystem and the people that interface to the system).

Appendix H contains the 2010 Turbo Architecture report of the complete list of the system inventory elements, and a detailed change log of all the changes made to the system inventory list can be found in Appendix I.

User Services

User services describe what functions intelligent transportation systems should perform from the user’s perspective. Users encompass a broad range of groups such as the traveling public, transportation agency personnel, emergency management personnel, and commercial vehicle operators. Although a user service is a functional requirement of the system, it does not describe where components fit into the architecture or how the service will be implemented. Selection of user services provides a high-level means of identifying the services to provide that address the statewide user needs and problems. To simplify the range of requirements in a broad area of services, the user services are logically grouped into eight user service bundles.

Table 6 includes these 2010 user service bundles and the 33 nationally defined user services and indicates the status of each one based on input from the Statewide Architecture Committee. A description of each user service may be found on the National ITS Architecture website[11].

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[11] *User Services*. U.S. Department of Transportation. Jan. 7, 2009. http://itsarch.iteris.com/itsarch/html/user/userserv.htm. Accessed Dec. 3, 2010.

Table 6. User Services in the Oregon Statewide ITS Architecture (2010)

User Services Bundles and User Services		Status
1	Travel and Traffic Management	
1.1	Pre-Trip Travel Information	Existing
1.2	En-Route Driver Information	Existing/Future
1.3	Route Guidance	Existing/Planned
1.4	Ride Matching and Reservation	Planned
1.5	Traveler Services Information	Existing/Planned
1.6	Traffic Control	Existing
1.7	Incident Management	Existing
1.8	Travel Demand Management	Future
1.9	Emissions Testing and Mitigation	Not Planned
1.10	Highway Rail Intersection	Future
2	Public Transportation Management	
2.1	Public Transportation Management	Existing/Planned
2.2	En-Route Transit Information	Existing/Planned
2.3	Personalized Public Transit	Existing/Planned
2.4	Public Travel Security	Existing/Planned
3	Electronic Payment	
3.1	Electronic Payment Services	Existing/Planned
4	Commercial Vehicle Operations	
4.1	Commercial Vehicle Electronic Clearance	Existing
4.2	Automated Roadside Safety Inspection	Not Planned
4.3	On-Board Safety and Security Monitoring	Not Planned
4.4	Commercial Vehicle Administrative Process	Existing
4.5	Hazardous Materials Security and Incident Response	Existing
4.6	Freight Mobility	Not Planned
5	Emergency Management	
5.1	Emergency Notification and Personal Security	Existing/Programmed
5.2	Emergency Vehicle Management	Existing
5.3	Disaster Response and Evacuation	Not Planned
6	Advanced Vehicle Safety Systems	
6.1	Longitudinal Collision Avoidance	Not Planned
6.2	Lateral Collision Avoidance	Not Planned
6.3	Intersection Collision Avoidance	Future
6.4	Vision Enhancement for Crash Avoidance	Not Planned
6.5	Safety Readiness	Not Planned
6.6	Pre-Crash Restraint Development	Not Planned
6.7	Automated Vehicle Operation	Not Planned
7	Information Management	
7.1	Archived Data	Existing/Planned
8	Maintenance and Construction Management	
8.1	Maintenance and Construction Operations	Existing

Market Packages

Market packages are deployment-oriented groupings of physical architecture entities that address specific user services. The user services identified in the previous section are too broad in scope to aid in the planning of actual deployments. Market packages are made up of one or more equipment packages that work together to deliver a transportation service and the architecture flows that connect them with subsystems and terminators. Figure 6 illustrates a sample market package that includes subsystems (the large rectangular boxes), the equipment packages (the small rectangular boxes), the terminators (the ovular boxes), and the architecture flows (the arrows).

The status of market packages previously selected for Oregon were reviewed and newer market packages were also reviewed and selected based on statewide needs. Table 7 lists the market packages selected by the Statewide Architecture Committee and includes both existing market packages already deployed and market packages that will be deployed within the next 10 years. Eight broad categories of interest are used to group the 91 market packages. Appendix J contains the 2010 Turbo Architecture market packages report, which includes a brief description of each market package, its statewide status, the applicable statewide inventory elements associated with the market package, and any comments on how the market package applies to Oregon. Appendix K includes the change log of all the changes made to the market packages prior to 2010. Additional details about each market package may also be found on the National ITS Architecture website[12].

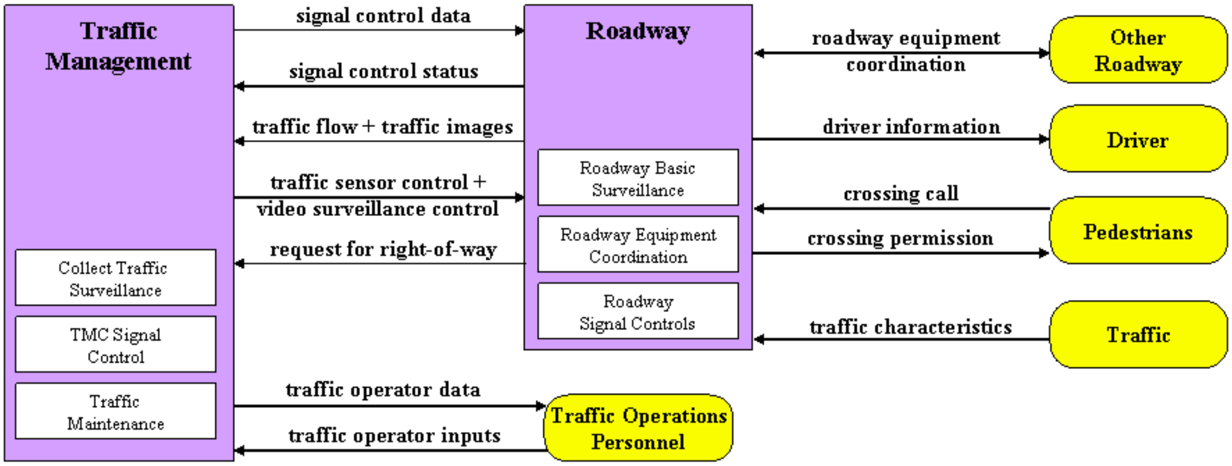

Figure 6. Sample Market Package Graphic: Surface Street Control (ATMS03)[13]

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[12] *Market Packages*. U.S. Department of Transportation. Jan. 7, 2009. http://itsarch.iteris.com/itsarch/html/mp/mpindex.htm. Accessed Dec. 3, 2010.

[13] *ATMS03- Surface Street Control*. U.S. Department of Transportation. Jan. 7, 2009. http://itsarch.iteris.com/itsarch/html/mp/gatms03.htm. Accessed Dec. 3, 2010.

Table 7. Market Packages in the Oregon Statewide ITS Architecture (2010)

Market Packages		Addition to Turbo Architecture	Status
Archived Data (AD) Management			
AD1:	ITS Data Mart	Version 1.0/1.1	Existing/Programmed
AD2:	ITS Data Warehouse	Version 1.0/1.1	Existing/Planned
AD3:	ITS Virtual Data Warehouse	Version 1.0/1.1	Not Planned
Advanced Public Transportation Systems (APTS)			
APTS01:	Transit Vehicle Tracking	Version 1.0/1.1	Existing/Planned
APTS02:	Transit Fixed-Route Operations	Version 1.0/1.1	Existing/Planned
APTS03:	Demand Response Transit Operations	Version 1.0/1.1	Existing/Planned
APTS04:	Transit Fare Collection Management	Version 1.0/1.1	Existing/Planned
APTS05:	Transit Security	Version 1.0/1.1	Existing/Planned
APTS06:	Transit Fleet Management	Version 1.0/1.1	Existing/Planned
APTS07:	Multi-Modal Coordination	Version 1.0/1.1	Existing/Planned
APTS08:	Transit Traveler Information	Version 1.0/1.1	Existing/Programmed
APTS09:	Transit Signal Priority	Version 4.0	Existing/Planned
APTS10:	Transit Passenger Counting	Version 4.0	Planned
Advanced Traveler Information Systems (ATIS)			
ATIS01:	Broadcast Traveler Information	Version 1.0/1.1	Existing
ATIS02:	Interactive Traveler Information	Version 1.0/1.1	Existing/Planned
ATIS03:	Autonomous Route Guidance	Version 1.0/1.1	Not Planned
ATIS04:	Dynamic Route Guidance	Version 1.0/1.1	Not Planned
ATIS05:	ISP Based Trip Planning and Route Guidance	Version 1.0/1.1	Not Planned
ATIS06:	Transportation Operations Data Sharing	Version 4.0	Existing/Planned
ATIS07:	Yellow Pages and Reservation	Version 1.0/1.1	Planned
ATIS08:	Dynamic Ridesharing	Version 1.0/1.1	Planned
ATIS09:	In Vehicle Signing	Version 1.0/1.1	Future
ATIS10:	VII Traveler Information	Version 4.0	Not Planned
Advanced Traffic Management Systems (ATMS)			
ATMS01:	Network Surveillance	Version 1.0/1.1	Existing
ATMS02:	Traffic Probe Surveillance	Version 1.0/1.1	Existing/Planned
ATMS03:	Surface Street Control	Version 1.0/1.1	Existing
ATMS04:	Freeway Control	Version 1.0/1.1	Existing
ATMS05:	HOV Lane Management	Version 1.0/1.1	Not Planned
ATMS06:	Traffic Information Dissemination	Version 1.0/1.1	Existing
ATMS07:	Regional Traffic Management	Version 1.0/1.1	Existing
ATMS08:	Traffic Incident Management System	Version 1.0/1.1	Existing
ATMS09:	Traffic Decision Support and Demand Management	Version 1.0/1.1	Future
ATMS10:	Electronic Toll Collection	Version 1.0/1.1	Existing/Planned
ATMS11:	Emissions Monitoring and Management	Version 1.0/1.1	Not Planned

Market Packages		Addition to Turbo Architecture	Status
ATMS12:	Roadside Lighting System Control	Version 4.0	Not Planned
ATMS13:	Standard Railroad Grade Crossing	Version 1.0/1.1	Not Planned
ATMS14:	Advanced Railroad Grade Crossing	Version 1.0/1.1	Not Planned
ATMS15:	Railroad Operations Coordination	Version 1.0/1.1	Future
ATMS16:	Parking Facility Management	Version 1.0/1.1	Planned
ATMS17:	Regional Parking Management	Version 1.0/1.1	Not Planned
ATMS18:	Reversible Lane Management	Version 1.0/1.1	Not Planned
ATMS19:	Speed Monitoring	Version 2.0	Existing
ATMS20:	Drawbridge Management	Version 2.0	Not Planned
ATMS21:	Roadway Closure Management	Version 3.0	Existing/Programmed
Advanced Vehicle Safety Systems (AVSS)			
AVSS01:	Vehicle Safety Monitoring	Version 1.0/1.1	Not Planned
AVSS02:	Driver Safety Monitoring	Version 1.0/1.1	Not Planned
AVSS03:	Longitudinal Safety Warning	Version 1.0/1.1	Not Planned
AVSS04:	Lateral Safety Warning	Version 1.0/1.1	Not Planned
AVSS05:	Intersection Safety Warning	Version 1.0/1.1	Future
AVSS06:	Pre-Crash Restraint Deployment	Version 1.0/1.1	Not Planned
AVSS07:	Driver Visibility Improvement	Version 1.0/1.1	Not Planned
AVSS08:	Advanced Vehicle Longitudinal Control	Version 1.0/1.1	Not Planned
AVSS09:	Advanced Vehicle Lateral Control	Version 1.0/1.1	Not Planned
AVSS10:	Intersection Collision Avoidance	Version 1.0/1.1	Future
AVSS11:	Automated Highway System	Version 1.0/1.1	Not Planned
AVSS12:	Cooperative Vehicle Safety Systems	Version 4.0	Not Planned
Commercial Vehicle Operations (CVO)			
CVO01:	Fleet Administration	Version 1.0/1.1	Not Planned
CVO02:	Freight Administration	Version 1.0/1.1	Not Planned
CVO03:	Electronic Clearance	Version 1.0/1.1	Existing
CVO04:	CV Administrative Processes	Version 1.0/1.1	Existing
CVO05:	International Border Electronic Clearance	Version 1.0/1.1	Not Planned
CVO06:	Weigh-in-Motion	Version 1.0/1.1	Existing
CVO07:	Roadside CVO Safety	Version 1.0/1.1	Not Planned
CVO08:	On-Board CVO and Freight Safety and Security	Version 1.0/1.1	Not Planned
CVO09:	CVO Fleet Maintenance	Version 1.0/1.1	Not Planned
CVO10:	HAZMAT Management	Version 1.0/1.1	Not Planned
CVO11:	Roadside HAZMAT Security Detection and Mitigation	Version 3.0	Not Planned
CVO12:	CV Driver Security Authentication	Version 3.0	Not Planned
CVO13:	Freight Assignment Tracking	Version 3.0	Not Planned
Emergency Management (EM)			
EM01:	Emergency Call-Taking and Dispatch	Version 1.0/1.1	Existing

Market Packages		Addition to Turbo Architecture	Status
EM02:	Emergency Routing	Version 1.0/1.1	Existing/Planned
EM03:	Mayday and Alarms Support	Version 1.0/1.1	Existing/Programmed
EM04:	Roadway Service Patrols	Version 2.0	Existing
EM05:	Transportation Infrastructure Protection	Version 3.0	Existing/Future
EM06:	Wide-Area Alert	Version 3.0	Existing
EM07:	Early Warning System	Version 3.0	Not Planned
EM08:	Disaster Response & Recovery	Version 3.0	Not Planned
EM09:	Evacuation and Reentry Management	Version 3.0	Planned
EM10:	Disaster Traveler Information	Version 3.0	Not Planned
Maintenance and Construction (MC) Management			
MC01:	Maintenance and Construction Vehicle and Equipment Tracking	Version 2.0	Planned
MC02:	Maintenance and Construction Vehicle Maintenance	Version 2.0	Not Planned
MC03:	Road Weather Data Collection	Version 2.0	Existing
MC04:	Weather Information Processing and Distribution	Version 3.0	Planned
MC05:	Roadway Automated Treatment	Version 2.0	Existing/Planned
MC06:	Winter Maintenance	Version 2.0	Future
MC07:	Roadway Maintenance and Construction	Version 2.0	Existing/Future
MC08:	Work Zone Management	Version 2.0	Existing/Planned
MC09:	Work Zone Safety Monitoring	Version 2.0	Existing/Future
MC10:	Maintenance and Construction Activity Coordination	Version 2.0	Existing/Programmed
MC11:	Environmental Probe Surveillance	Version 4.0	Not Planned
MC12:	Infrastructure Monitoring	Version 4.0	Not Planned

High-Level Physical Architecture Interconnects

Figure 7 illustrates the subsystems and architecture interconnects that make up the high-level physical architecture for Oregon in 2010. This figure includes both existing and planned physical entities. The following general updates were made to the architecture interconnects:

- Update of interconnects to reflect changes to the system inventory.
- Tailoring of the new interconnects to the system inventory as applicable.
- Review of interconnects for completeness and accuracy.

Architecture interconnects have been included in the Turbo Architecture database that link the Oregon Statewide ITS Architecture to the regional architectures within the state and to the statewide architectures of neighboring states.

Appendix L includes the 2010 Turbo Architecture report for the architecture interconnects that carry architecture flows between the subsystems and terminators and Appendix M includes the 2010 architecture flows. There are far too many architecture interconnects to depict in a single graphic or to document in a change log.

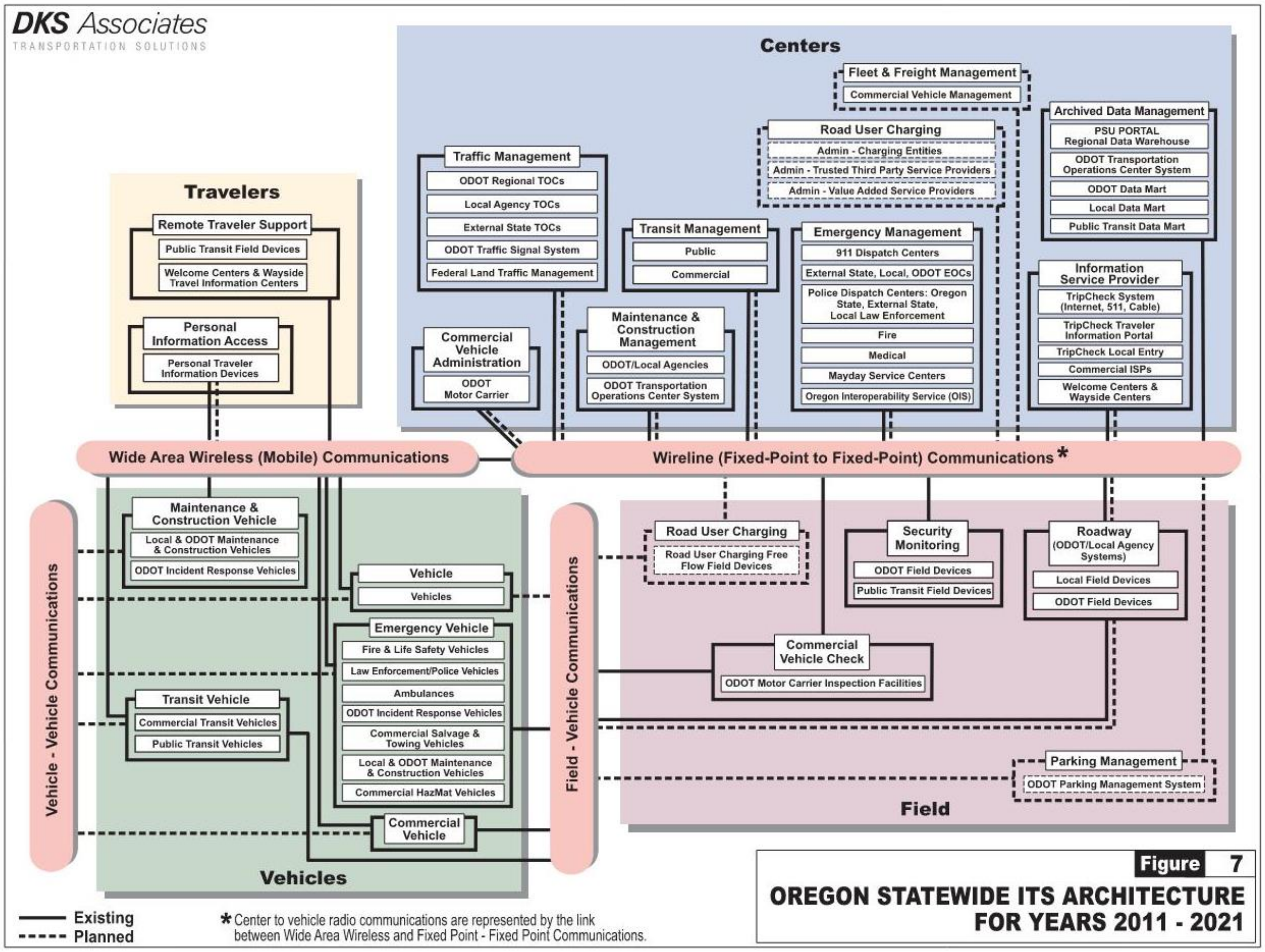

Figure 7. Oregon Statewide ITS Architecture for Years 2011 - 2021

Functional Requirements

ODOT identifies functional requirements as part of their systems engineering process at the project level for statewide significant systems with interfaces that cross agency boundaries. Therefore, functional requirements are not included as part of the Oregon Statewide ITS Architecture.

OPERATIONAL CONCEPT PLAN

This section includes a summary of the ITS operational concept for the state of Oregon, which is an overview of how the state's stakeholders and systems work together to provide ITS services. The main objectives of the operational concept are to:

- Identify current and future stakeholder roles and responsibilities in the implementation and operation of regional and statewide systems[14].
- Achieve buy-in on these roles and responsibilities and lay the groundwork for future agency agreements[14].
- Document and communicate statewide ITS strategies.
- Provide a clear framework for coordination between statewide and regional strategies.

Additionally, an operational concept has been added as a required component of a regional/ statewide ITS architecture per the FHWA Final Rule and FTA Policy since the Oregon Statewide ITS Architecture was originally created.

This section documents the operational concept development approach and agency roles and responsibilities for the ITS service areas identified in the scope of the architecture.

Introduction

The deployment of ITS projects is unique because many of the benefits are realized only when ITS projects are implemented together on a regionwide or statewide basis, rather than on an individual basis. As a result, the implementation of ITS projects requires coordination and ongoing cooperation between various agencies within Oregon and across state boundaries. The ITS operational concept presented in this report provides an overview of ITS programs that require regional or statewide coordination and cooperation, such as providing traveler information through the new TripCheck Traveler Information Portal. This ITS operational concept defines the roles and responsibilities of the key transportation, transit, and emergency management agencies and key private sector organizations over the next 10 years and identifies shared information flows between these agencies. It is not intended to describe agency-specific ITS systems such as the Port of Portland's airport parking system.

Operational Concept Development Approach

The statewide operational concept was developed based on input from the Statewide Architecture Committee and a review of ITS documents, which include statewide and regional ITS project documentation, regional ITS plans, and regional ITS architectures. The Statewide Architecture Committee and ITS documentation provided insight into stakeholder roles and responsibilities as well as consensus. The results discussed in the operational concept may not represent all of the potential interactions, but present key relationships, roles and responsibilities, and information flows that make up a day in the life of ITS in Oregon.

Implementation and operation of ITS in Oregon on a daily basis involves numerous stakeholders and intelligent transportation systems. So much so that it would be too complex and difficult to manage an operational concept that describes all ITS activities as a single operational concept. Therefore, the Oregon statewide operational concept has been split into

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[14] *Regional ITS Architecture Guidance: Developing, Using, and Maintaining an ITS Architecture for Your Region*. Report FHWA-OP-02-024. U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, National ITS Architecture Team, Oct. 12, 2001.

several smaller service area operational concepts; each one covering a particular aspect of the transportation system. Operational concepts have been defined for each of the following ITS service areas:

- Transportation Operations Centers
- Regional Traffic Control
- Traveler Information
- Maintenance and Construction Operations
- Road Weather Operations
- Incident Management
- Emergency Management
- Archived Data Management
- Public Transportation
- Road User Charging
- Connected and Automated Vehicles

These service areas overlap in a number of areas and some of the individual operational concepts refer to other ones. For instance, components of all the service areas are tied in to ODOT's Transportation Operations Center Software project. Likewise, the functions of the traveler information operational concept are used to provide information about most of the other service areas (e.g. incidents, maintenance and construction).

Each service area operational concept described in this report includes the following:

- General description of the service area based on the National ITS Architecture or CVRIA.
- A statewide vision for the service area and goals that support the vision.
- A summary of key issues facing the service area.
- High-level descriptions of the applications used today and planned for tomorrow.
- Detailed roles and responsibilities of key stakeholders.

Transportation Operations Centers (TOCs) Operational Concept

ODOT's regional transportation operations centers (TOCs) and other TOCs (local traffic management agencies and external state departments of transportation) are the hub for the operations, management, and maintenance activities related to the Oregon transportation network. This TOCs section includes the vision, current applications, current issues, future applications, and stakeholder roles and responsibilities.

Transportation Operations Centers Vision

The vision for TOCs in Oregon is for ODOT, local traffic management agencies, and neighboring states to actively coordinate the day-to-day operations of the transportation infrastructure and respond to events[15] within their own jurisdictions and across jurisdictional boundaries through regional partnerships. ODOT's vision is to use the Transportation Operations Center System (TOCS), which is a comprehensive hardware and software platform for all ODOT TOCs, to provide "a unified, statewide platform for around the clock coordination of transportation related services between internal and external customers."[16] The following goals support the statewide vision:

- Use TOCS to integrate traffic management, incident management, and event response applications to support efficient and safe travel as well as maintenance activity management and information dissemination.
- Implement TOCS so that each ODOT TOC may operate autonomously with the ability to provide back-up for the other regional ODOT TOCs.
- Facilitate shared responses between ODOT regional centers.
- Establish public and private partnerships to support coordinated cross-jurisdictional traffic control/operations and event response.
- Implement ITS standards (e.g. incident management message sets) as a part of TOCS and local TOC systems.
- Standardize operational procedures throughout Oregon.
- Automate electronic information exchange and device control (as applicable) between centers/systems (e.g. TOCs, Oregon State Police, 911 centers, emergency operations centers, etc.)
- Develop management reporting capabilities for measurement of metrics/performance and to support decision making.

The goals listed above are high-level goals pertaining to the TOCs. Many of the specific goals included in the operational concepts for the other service areas also pertain to the TOCs since the TOCs play an integral part in all of the other service areas selected for the Oregon Statewide ITS Architecture.

Transportation Operations Centers Applications Today

TOCs are operated today by ODOT, local traffic management agencies, and external state DOTs. The following describes the applications used at each type of TOC:

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[15] An "event" is considered any non-standard occurrence such as an incident, special event (e.g. fair, sports match, concert), maintenance/construction activity, inclement weather, or a major emergency that occurs on or affects the roadway.

[16] *Transportation Operations Center System Concept of Operations, Final Version*. Oregon Department of Transportation, ITS Unit, Nov. 10, 2004.

- **ODOT TOCs:** ODOT operates a TOC for each of its five regions as generally described in Table 8[17]. Overall the TOCs perform the following functions for the state highway system:
  - *Traffic Management:* Operation of traffic control devices.
  - *Incident Management:* Detection/identification, response (e.g. dispatch), and management of incidents.
  - *Maintenance Support:* Dispatch and communications for ODOT maintenance crews.
  - *Information Service Provider:* Dissemination of traveler information to the public regarding events that impact the roadway.

The Transportation Operations Center System (TOCS) is used by all ODOT TOCs for incident management, maintenance support, and information provision to the public. The main platform used for traffic management is the TransPort Advanced Traffic Management System (ATMS) software used by the Region 1 TMOC. Supplemental systems are used as well but are not described here in detail since ODOT is currently working to implement additional features of one common system at all its TOCs as described in the Transportation Operations Centers Applications Tomorrow section[18].

Table 8. Overview of ODOT Transportation Operations Centers

ODOT TOC	Hours of Operation	Primary Responsibility	Back-Up Responsibility
Region 1 TMOC (Portland)	▪ All hours, all days	▪ Region 1	▪ none
Region 2 NWTOC (Salem)	▪ All hours, all days	▪ Region 2	▪ Regions 1, 3, 4, 5
Region 3 TOC (Central Point)	▪ All hours, all days	▪ Region 3 ▪ District 11 (located in Region 4)	▪ Regions 4 & 5 ▪ District 5 (located in Region 2)
Region 4 TOC (Bend)	▪ All hours, all days	▪ Region 4 ▪ Region 5 after hours	▪ Regions 2, 3, 5
Region 5 Virtual TOC (District Offices)	▪ 9 hr/5 days*	▪ Region 5	▪ Region 4

* Although Region 5 does not have a formal TOC, the District Offices (Districts 12 and 13) within Region 5 operate as TOCs during normal business hours except they do not currently have access to LEDS and do not dispatch incident management vehicles/personnel.

- **Local Traffic Management Agency TOCs:** A variety of TOCs are currently used throughout Oregon by Cities, Counties, and Port Authorities. Some agencies have a physical center (e.g. City of Portland, Port of Portland) while others have virtual TOCs that consist of a workstation(s) with desktop access to an agency's traffic signals and field devices (e.g. Clackamas County, City of Eugene). A number of agencies have identified TOC or virtual TOC projects in their regional ITS architectures. Most of the local traffic management agency TOCs solely perform traffic management functions, but some perform incident management, maintenance management, and information service provider functions on a limited basis. A few agencies in the Portland metropolitan area (e.g. City of Portland, Clackamas County) have access to the ATMS software used

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[17] *Transportation Operations Center Concept of Operations*. Oregon Department of Transportation. May 2010.
[18] *Transportation Operations Center System Assessment of the Current System (P120S), ver. 2.0*. Prepared by TransCore for the Oregon Department of Transportation, Feb. 21, 2003.

by the ODOT Region 1 TMOC and have agreements in place for device sharing (e.g. CCTV camera pan/tilt/zoom functionality).

- **External State DOT TOCs:** Neighboring states (Washington, Idaho, Nevada, and California) operate TOCs that perform similar statewide functions as the ODOT TOCs. ODOT coordinates with these TOCs when day-to-day operations or events impact interstate travel. The Washington State Department of Transportation (WSDOT) Southwest Region TOC in Vancouver also has access to the ATMS software used by the ODOT Region 1 TMOC and has agreements in place for device sharing (e.g. CCTV camera pan/tilt/zoom functionality).

Transportation Operations Centers Issues

Current issues associated with TOCs in Oregon include the following:

- Nationwide, congestion caused 3.5 billion hours of delay and wasted 5.7 billion gallons of fuel in year 2002 costing the nation $63.2 billion (year 2002 dollars)[19]. Over half of congestion is caused by non-recurring events as shown in Figure 8. Non-recurring congestion, and its negative impacts, can be reduced by developing and utilizing strategies described in the operational concepts for most of the other service areas and implementing many of them throughout Oregon at the TOCs.

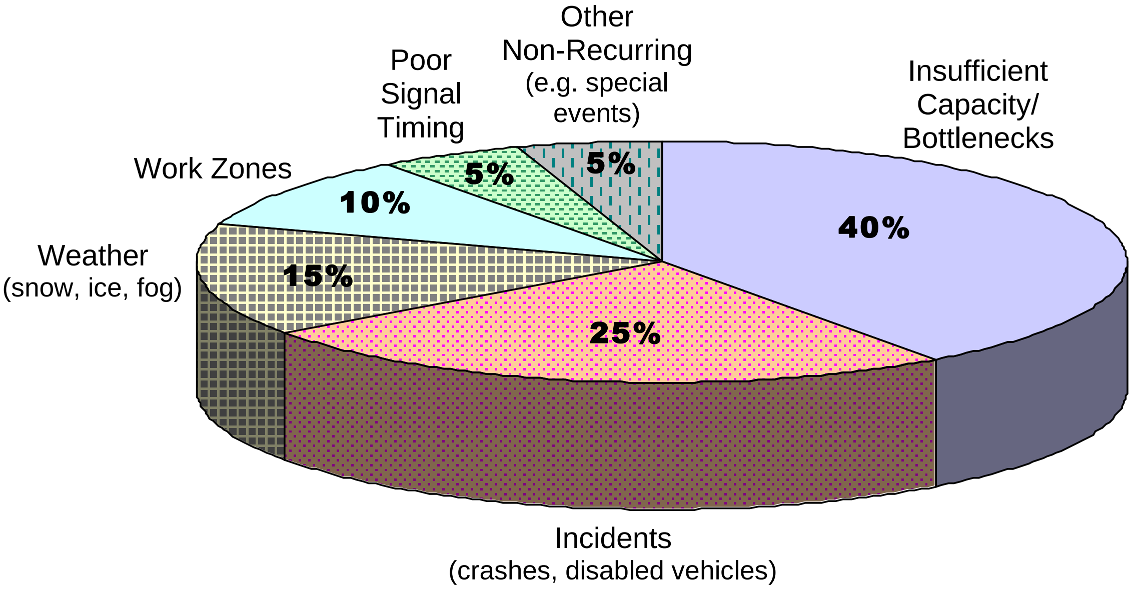

Figure 8. Causes of Congestion[20]

- Non-recurring events and their ripple effects dramatically reduce the available capacity and reliability of the entire transportation system. Travelers and shippers are especially sensitive to the unanticipated disruptions to tightly scheduled personal activities and manufacturing distribution procedures.
- Transportation forecasting models show that currently planned transportation investments will not keep up with traffic growth in Oregon's major metropolitan areas, which will result in severe recurring congestion delays. This will affect how well the State

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[19] Schrank, D. and T. Lomax. *The 2004 Urban Mobility Report*. Texas Transportation Institute, Texas A&M University, Sept. 2004.

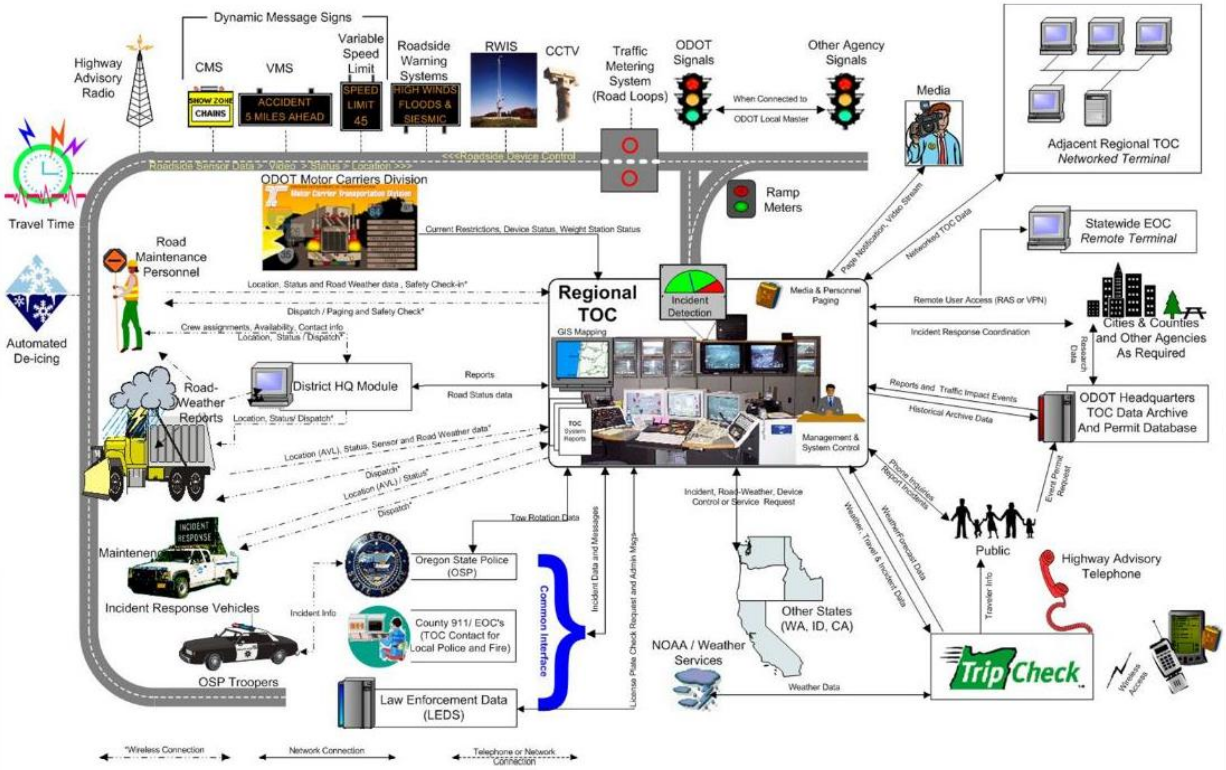
[20] *Congestion Mitigation*. Office of Operations, Federal Highway Administration. http://www.ops.fhwa.dot.gov/congestionmitigation/congestionmitigation.htm. Accessed March 29, 2006.

can compete for new jobs and will cost each household additional dollars that result from the additional travel time, travel cost, and crashes that congestion causes.

- The lack of a common operating platform at ODOT TOCs creates a number of challenges, which all reduce the efficiency of the services provided:
  - Different operating procedures at the TOCs results in inconsistent responses throughout the state.
  - Back-up capabilities between TOCs are limited.
  - Efforts are duplicated when software packages are developed for different TOCs that use similar functionality.
  - There is a lack of integration and information sharing between systems (traffic management, incident/emergency management, maintenance and construction operations, and traveler information dissemination).
  - Communication systems are not integrated and a number of functions are still performed over the telephone. This creates a gap in activity tracking for auditing purposes.
  - Systems are not optimized for event response, particularly maintenance and construction operations.
  - The reporting capabilities for metrics/performance measurement and operations management decision making are limited.
- In general there is a need for more integration and information sharing between all TOCs throughout Oregon and other centers (e.g. 911 centers, Oregon State Police, emergency operations centers). Coordination with emergency operations centers is particularly important when dealing with disasters and emergencies. For example, extensive cross-jurisdictional coordination was required in the U.S. during the September 11th, 2001 terrorist attacks and during Hurricanes Katrina and Rita in 2005.

Transportation Operations Centers Applications Tomorrow

The main application of tomorrow is the full deployment of the Transportation Operations Center System (TOCS) that ODOT is currently developing in phases to provide a common, integrated system for use at ODOT TOCs statewide. The system also supports a field office module for use by region managers, area offices, district offices, Salem/headquarters offices, public information officers, and the Motor Carrier Division. Figure 9 illustrates ODOT’s concept of operations for its regional TOCs and Table 9 includes a high-level summary of the functions TOCS performs today and will perform in the future. TOCS will continue to be implemented in several stages and will fulfill the vision and goals described earlier in this section.



Source: *Transportation Operations Center System Concept of Operations, Final Version.*
Oregon Department of Transportation, ITS Unit, Nov. 10, 2004.

Figure 9
ODOT REGIONAL TOC
CONCEPT OF OPERATIONS

Figure 9. ODOT Regional TOC Concept of Operations

Table 9. Summary of TOCS Functions[21]

Functional Area	**TOCS Functions *(planned functions shown in italics)***
Traffic Management	▪ *Monitor operational status of traffic signals, provide alerts based on pre-defined conditions, and provide information on traffic pattern changes for future timing updates.* ▪ *Manage ramp meter operations, adapt timings to actual conditions, suggest alternative timing plans in response to incidents, and provide control interface.* ▪ *Manage DMS message library and provide control interface.* ▪ *Provide control interface with variable speed limit signs, archive date and time of speed zone changes, and notify enforcement agencies of speed limit changes.*
Incident Management	▪ Manage incident notification call out lists and support paging. ▪ Notify ODOT PIO of incidents, distribute press releases. ▪ Generate maintenance tracking logs. ▪ Provide templates for property damage forms. ▪ *Automate media paging.* ▪ *Monitor detection sensors and report potential incidents.* ▪ *Suggest pre-planned response plans and enable automated responses where appropriate.*
Emergency Management	▪ *Same functions as incident management with an emphasis on implementing emergency operations plans.*
Maintenance Operations	▪ Manage and store contact/call out information and manage security of personal information (e.g. home telephone numbers). ▪ Provide notification for critical maintenance needs and provide incident reports. ▪ Track vehicle location and activity and archive data. ▪ Display available and assigned crews/individuals. ▪ Automate maintenance activity reports. ▪ Forward activities impacting travel to TTIP. ▪ *Display vehicle location on map.* ▪ *Provide automated system to call back GPS coordinates for current crew/individual locations.*
Winter Operations	▪ Monitor weather sensors and report potential winter driving hazards. ▪ Provide potential alarm for severe weather based on location and environmental sensor device specific criteria. ▪ Display available and assigned crews/individuals. ▪ *Change DMS messages based on weather/chain restrictions entered in system.*
Device Mgmt	▪ *Automatically detect failures and create notification alarms for ramp meters, environmental sensors, and DMS.* ▪ *Log failures/status of ramp meters, environmental sensors, RWIS, and DMS when polled.* ▪ *Provide control interface for CCTV, DMS, and PVMS.* ▪ *Automate DMS travel time messages in urban areas.* ▪ *Track PVMS deployment locations and status and manage message library.*
Traveler Information	▪ Manage incident data, automate reporting to ISP, LEDS, and NOAA, and notify media based on severity. ▪ Manage maintenance and construction data and height/width restrictions and automate reporting to ISP. ▪ *Manage RWIS data, automate RWIS reporting to ISP, LEDS, and NOAA, notify TOC operator of reports, and notify media based on severity.*

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[21] *Transportation Operations Center System Concept of Operations, Final Version*. Oregon Department of Transportation, ITS Unit, Nov. 10, 2004.

Functional Area	TOCS Functions *(planned functions shown in italics)*
	▪ *Determine travel times and automate reporting to ISP.*
Data Archival and Reporting	▪ Automate back-ups of current and archival data. ▪ Automate purging of historical records to an archival system.

Stakeholder Roles and Responsibilities

The key stakeholder roles and responsibilities for the transportation operations centers service area are listed in Table 10.

Table 10. Transportation Operations Centers Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation	▪ Develop, implement, operate and maintain TOCS.	▪ Existing/Planned
	▪ Actively monitor and manage the ODOT roadway network (e.g. video, traffic flow conditions, road/ weather conditions).	▪ Existing
	▪ Manage/control freeway ramp meter system and SWARM module.	▪ Existing (Reg. 1)/ Future (Reg. 2)
	▪ Implement coordinated traffic signal timing plans for incidents.	▪ Future
	▪ Provide incident management capabilities (e.g. detection, verification, response, on-site assistance). This includes dispatching ODOT incident responders, ODOT maintenance crews, and towing/salvage operators.	▪ Existing/Planned
	▪ Monitor and manage maintenance work, construction activities, and road closures.	▪ Existing
	▪ Manage and dispatch ODOT maintenance crews.	▪ Existing
	▪ Disseminate traffic information to travelers (e.g. DMS, TripCheck).	▪ Existing
	▪ Coordinate with other ODOT TOCs, Local TOCs, External State TOCs, OSP, Emergency and Incident Management Teams, and 911 centers.	▪ Existing
	▪ Take calls from the public and the media.	▪ Existing
Local Traffic Management Agencies	▪ Actively monitor and manage the local roadway network (e.g. video, traffic flow conditions, road/weather conditions).	▪ Existing/ Programmed
	▪ Implement coordinated traffic signal timing plans for incidents.	▪ Existing/Future
	▪ Provide incident management capabilities (e.g. detection, verification, response, on-site assistance). This includes dispatching local incident responders and maintenance crews.	▪ Existing/Planned
	▪ Monitor and manage maintenance work, construction activities, and road closures.	▪ Existing/Planned

Stakeholder	Roles and Responsibilities	Status
	▪ Disseminate traffic information to travelers (e.g. DMS, local agency website, TTIP). ▪ Coordinate with Regional ODOT TOCs, other Local TOCs, and 911 centers. ▪ Take calls from the public and the media.	▪ Existing/Planned ▪ Existing/Planned ▪ Existing
External State Departments of Transportation	▪ Actively monitor and manage the DOT roadway network (e.g. video, traffic flow conditions, road/weather conditions). ▪ Manage/control freeway ramp meter system. ▪ Provide incident management capabilities (e.g. detection, verification, response, on-site assistance). This includes dispatching incident responders, maintenance crews, and towing/salvage operators. ▪ Monitor and manage maintenance work, construction activities, and road closures. ▪ Manage and dispatch DOT maintenance crews. ▪ Disseminate traffic information to travelers (e.g. DMS, state DOT website, TTIP). ▪ Coordinate with ODOT TOCs, State Police, Emergency and Incident Management Teams, and 911 centers. ▪ Take calls from the public and the media.	▪ Existing ▪ Existing/Planned ▪ Existing ▪ Existing ▪ Existing ▪ Existing/Planned ▪ Existing ▪ Existing

Regional Traffic Control Operational Concept

Unlike any other state in the nation, public agencies in Oregon have a long tradition of utilizing common traffic signal control systems and devices across the state. Interagency coordination and information exchanges are critical to supporting regional traffic control management and responses. Common standards-based traffic control and surveillance systems across Oregon will support an integrated response to maintain local, regional and statewide travel times. This regional traffic control section includes the vision, current applications, current issues, future applications, and stakeholder roles and responsibilities. Figure 10 depicts the regional traffic control operational concept[22].

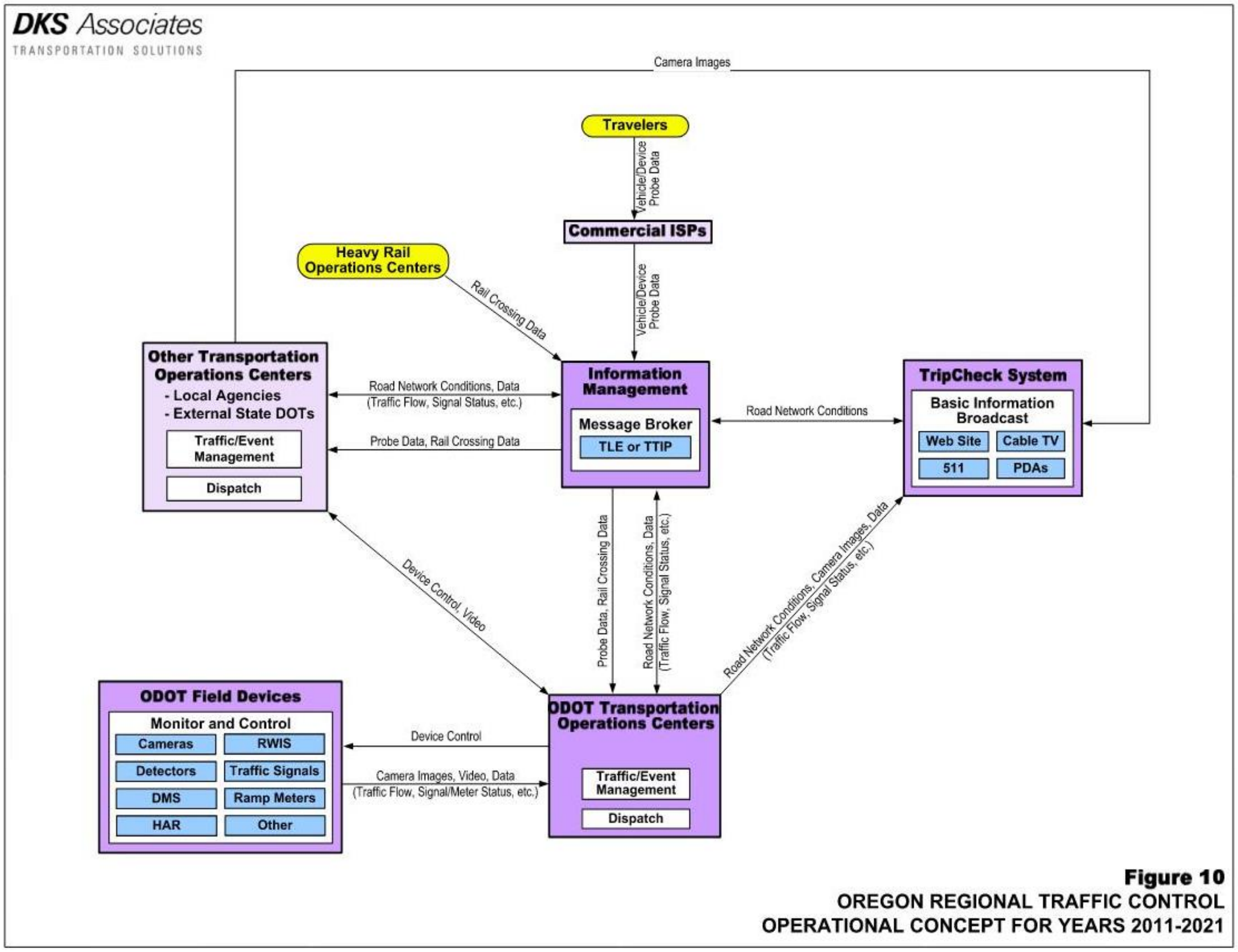

Figure 10. Oregon Regional Traffic Control Operational Concept for Years 2011 - 2021

Regional Traffic Control Vision

The regional traffic control vision is for public agencies to manage and respond to the dynamic traffic conditions of Oregon’s transportation network through cross-jurisdictional coordination, information sharing, and the use of integrated and automated systems while also improving and maintaining travel time reliability. Goals that support this vision include the following:

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[22] “Traffic/Event Management” and “Dispatch” on Figure 10 represents all of the systems used at a TOC such as ATMS, TOCS, or other applications.

- Establish public agency partnerships and information exchanges to support regional traffic control and management strategies.
- Build on the long Oregon public agency tradition of utilizing common standards-based traffic control hardware and systems to support statewide traffic control and surveillance systems.
- Integrate multi-jurisdictional traffic control strategies with communication links between traffic operations/management centers, common information exchanges, and shared control of field devices.
- Integrate freeway and surface street systems so that traffic management is coordinated along a corridor that transitions between the two systems.
- Automate traffic signal control and freeway control responses so that traffic signals and ramp meters, working together, dynamically adjust to changes in vehicle volumes based on current, network-wide roadway conditions.
- Gather surface street and freeway information from multiple public and private sources to support network monitoring, data collection, event response, and dissemination of traveler information.
- Actively manage and respond to transportation system conditions to maintain travel time reliability and preserve existing system capacity.

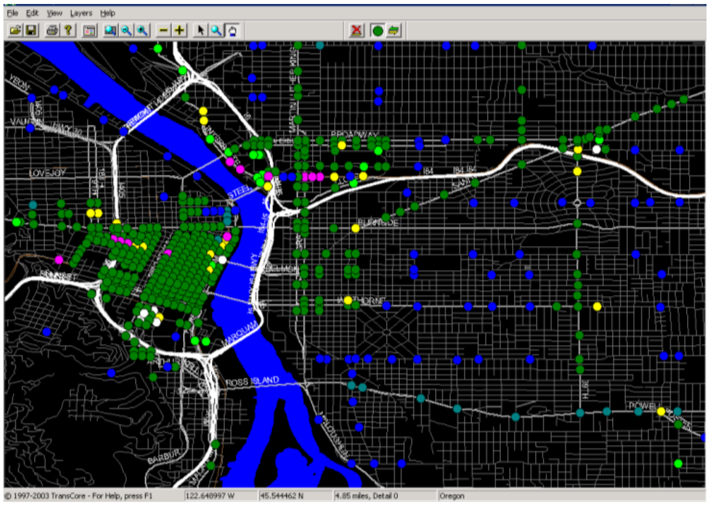
Regional Traffic Control Applications Today

Regional traffic control applications in use today include regional traffic signal control, freeway control, network surveillance, and probe surveillance.

Regional Traffic Signal Control: The State of Oregon has a long tradition of utilizing common traffic signal control hardware and software. Many agencies use or are migrating towards the use of a central signal system. The central traffic signal systems are used to monitor traffic signal operations, implement coordinated signal timing plans, implement adaptive signal timing, and collect volume, speed, and traffic density information from system detectors. The use of national standards is what allows agencies to share and control data electronically.

ODOT and other public agencies throughout the state operate common traffic signal control hardware and systems as follows:

- ODOT: ODOT has migrated from TransCore TransSuite central signal system to Q-Free MaxView central signal software system. Each Region is working on replacing Type 2070 traffic signal controllers with ATC controllers operating MaxTime and connecting them to the MaxView central system. ODOT currently has a single server operating MaxView that all regions can connect to. Note: ODOT plans to migrate to Q-Free Kinetic Signals, which will be a cloud-based central system, in the near future. Q-Free enables center-to-center connection between multiple MaxView (Kinetic) systems, which will allow ODOT Region 1 to share signal data with a number of agencies in the Portland metropolitan area. In concert with MaxTime, MaxAdapt is a local software that runs on the ATC and provides adaptive signal timing based on traffic conditions in real-time. Kinetic Signals also provides an Automated Traffic Signal Performance Measures (ATSPM) module that ODOT can use to operate, manage, and maintain the signal system more efficiently.



Portland Area Traffic Signal Control System

- Portland Metropolitan Area: The regional agencies have taken a unique approach to managing traffic signals for a major metropolitan area. Based on a long history of working together and sharing the same local traffic signal hardware and software, the Portland region has jointly decided to operate the signals on a common central traffic signal system. The agencies recently chose to replace the TransCore TransSuite central system with Q-Free Kinetics, similar to ODOT. This common central signal system provides the region with the unique opportunity to share resources required to manage and operate the region's traffic signals. The common system also supports back-up servers at separate physical locations in the region, and it supports shared control of traffic signal operations for special events or unplanned incidents. Clackamas County, Washington County, and the Cities of Portland and Gresham currently use the common central signal system.
- Cities of Eugene and Springfield: They operate common traffic signal systems and have communications to the majority of their signalized intersections.
- City of Medford: They operate a central traffic signal system from the same vendor as the Cities of Eugene and Springfield and they have communications to over 90 percent of their signalized intersections.

All major metropolitan areas in Oregon utilize coordinated signal timing plans on their major arterial roadways and this often includes the coordination of traffic signals operated by different jurisdictions that are located on the same corridor. Many of these plans are implemented based on the time of day and are not influenced by changes in traffic congestion; however, some agencies have installed or are currently installing adaptive signal timing on corridors with unpredictable traffic patterns. Adaptive signal timing systems adjust cycle lengths and phase splits based on real-time changing traffic conditions.

Freeway Control: Freeways in Oregon are generally better instrumented to monitor congestion than arterial roadways. Operators in ODOT's Transportation Operations Centers (TOCs) monitor and control Oregon's freeway and highway system using cameras, ramp meters, dynamic message signs, dynamic speed signs, ramp closure systems, and incident response vehicles. The TOC operators, in conjunction with emergency service providers, determine the best response to incidents and other events, which are described in other service area operational concepts. ODOT also uses the following applications:

- Incident Detection: The ODOT freeway management system utilizes algorithms to analyze data from the detection systems discussed under Network Surveillance and to provide an alert to TOC operators about potential incident locations. The Portland metropolitan area alone has over 485 detectors that report freeway volumes and vehicle speeds every 20 seconds.
- Adaptive Ramp Metering System: ODOT uses adaptive ramp metering algorithms at a number of freeway ramps in Portland that dynamically adjust the ramp metering rate in real-time based on current vehicle volumes and speeds. The metering rate at all other

freeway ramps is adjusted based on time-of-day. Ramp meters are located on almost every ramp in the Portland metropolitan area. Currently the Eugene-Springfield area is the only other part of the state that has deployed ramp meters.

Network Surveillance: Current network surveillance technologies used throughout Oregon include camera monitoring systems and detection systems for data collection:

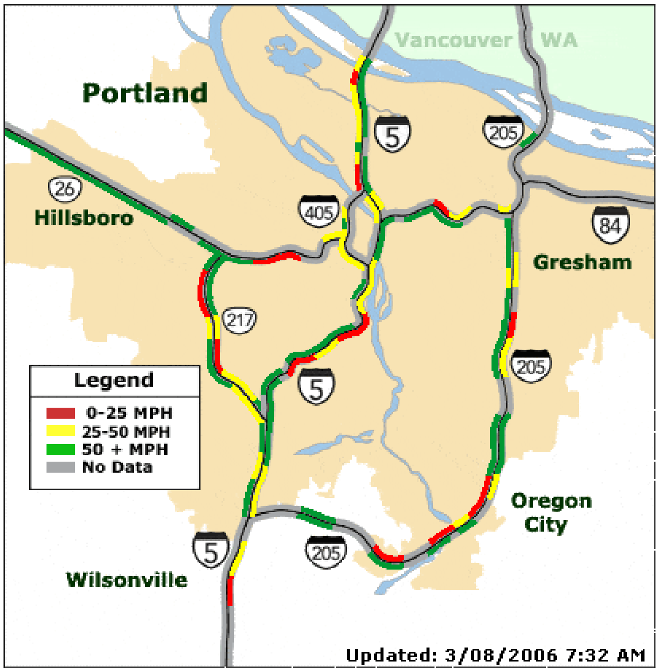
- Camera Monitoring Systems: These systems are in place at key points along many of ODOT's roadways throughout the state and a limited number of systems have been installed on County and City roadways. TOC operators use the camera systems to monitor road and traffic conditions and to identify and verify roadway hazards and incidents. Video images and camera control are shared on an interstate level (between ODOT, WSDOT and CalTrans), a statewide level (between ODOT TOCs), and on a local level (e.g. between ODOT Region 1 TMOC and the City of Portland).
- Detection Systems: These systems on major roadways provide volume, speed, and occupancy (vehicle density) information. Additionally, automated traffic recorders and weigh-in-motion systems collect classification information and system detector loops are also used to provide a traffic condition map for the Portland metropolitan area. ODOT has vehicle detection coverage on many of the major state highways. Other local agencies including Multnomah County and the Cities of Portland, Gresham, Salem, Eugene, Springfield and Medford currently have detection systems that provide volume, speed and occupancy information from central traffic signal systems. Most of the data collected on arterial roadways is not currently shared outside the local agency.

Probe Surveillance: This application area uses vehicles or personal digital devices to provide congestion related information and predicted travel times on arterial roadways. ODOT is currently implementing a pilot project to use Bluetooth devices as probes to provide congestion related information on Pacific Highway (OR 99W) in the City of Tigard.

Regional Traffic Control Issues

The prominent regional traffic control issues today include the following:

- Although ODOT and local traffic management agencies throughout the state have taken great strides to reduce the impacts of congestion, more efforts are needed to improve the efficiency of the statewide transportation network as congestion continues to increase. As previously discussed in the TOCs Operational Concept section, recurring and non-recurring congestion cause countless delays and economic impacts to travelers and freight.
- Real-time coordination is needed between freeway and arterial management systems. Coordinated traffic signal plans are not always



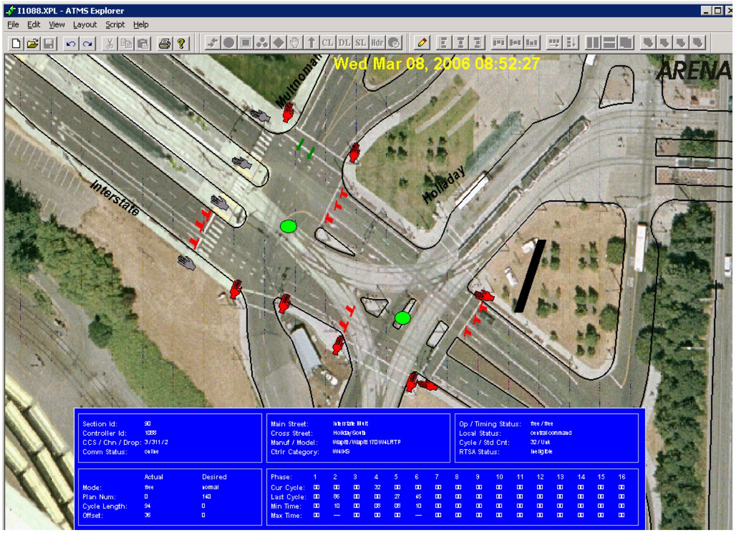
ODOT TripCheck Speed Map for Portland Metro Area able to accommodate congested conditions at freeway interchanges.

- TOC operators do not currently have the ability to implement alternate coordinated timing plans at traffic signals. Most signal timings are updated by engineers from their offices and only during normal business hours. This limits the ability of an agency to impact signal timing changes to improve traffic flow when needed.
- Surveillance coverage on arterial roadways is currently limited. Most surveillance efforts have been concentrated on the interstate system and major ODOT highways.
- Approximately half (21,000 of 43,000) of annual traffic fatalities on nationwide highways result from roadway departure and intersection related incidents[23]. Although these types of incidents typically occur due to driver error, communications between vehicles and roadside devices may help provide drivers with warnings and in turn reduce incidents and related fatalities.

Regional Traffic Control Applications Tomorrow

Regional traffic control functions tomorrow will incorporate significant integration between freeway and arterial management systems. Agencies will respond in real-time to events on the roadway network and manage traffic by dynamically adjusting signal timings, ramp meter timings and providing roadway condition information to travelers. Automotive and public agency initiatives will work toward the deployment of vehicle-to-vehicle and vehicle-to-infrastructure communications to enhance safety. This subsection includes an overview of the regional traffic control applications of tomorrow.

Regional Traffic Signal Control: Traffic signal controllers will utilize common standards and support multiple applications including adapting coordinated signal timings based on current traffic conditions. Public agencies will select the traffic signal control software that suits their application and needs and that software will communicate to a common central system and will support cross-jurisdictional coordination and control. Public agencies will share monitoring and control capabilities to implement traffic signal timing response plans to respond to incidents and special events. TOC operators will have the ability to implement special coordinated timing plans developed for alternate routes used during events that impact the roadway. Operations and maintenance of the central systems, servers and data storage servers will be shared by multiple agencies.



Section Id: 90
Controller Id: 1088
CCS / Chn / Drop: 3/311/2
Comm Status: online

Main Street: Interstate Mult
Cross Street: HollidaySouth
Manuf / Model: Wapiti/Wapiti 170 W4LRTP
Ctrlr Category: W4IKS

Op / Timing Status: free / free
Local Status: central command
Cycle / Std Cnt: 32 / Unk
RTSA Status: ineligible

	Actual	Desired
Mode:	free	normal
Plan Num:	0	140
Cycle Length:	94	0
Offset:	36	0

Phase:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cur Cycle:	□□	□□	□□	32	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Last Cycle:	□□	86	□□	□□	27	45	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Min Time:	□□	10	□□	08	08	10	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Max Time:	□□	—	□□	□□	□□	—	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□

City of Portland Intersection Control

Automated Traffic Signal Performance Measures (ATSPMs) provide high resolution data (collected by the ATC controllers) in the form of reports and graphs to illustrate different performance metrics. ATSPMs are a tool that help an agency make decisions related to operating and maintaining traffic signals based on real time data.

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[23] *Connected Vehicle*. ITS Joint Program Office, United States Department of Transportation. http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm. Accessed May 24, 2011.

Traffic volume, density and speed data collected by traffic signal systems will be easily accessible to support congestion mapping, traffic analysis and monitoring system performance measures (i.e. travel time reliability). Traffic volume turn movement counts and 24-hour counts will be collected and stored automatically by the traffic signal systems.

Detection systems will be developed and implemented for collecting reliable, real-time arterial congestion data. Traveler information maps will use the data collected by the traffic signal system detectors.

Freeway Control: Ramp meters will continue to automatically adjust the metering rate based on congestion measured on a system wide basis using the vehicle detection systems. Additional ramp metering systems are deployed in the Eugene-Springfield metropolitan area. Freeway control using ramp meters, detectors and traveler information devices will be integrated with arterial control (traffic signals, detectors and traveler information) to support event management operations and to support coordination between traffic signals and ramp meters. This integration will also minimize queue spillover on ramps and arterial roadways at freeway interchange terminals.

Freeway, Highway, and Street Surveillance: ODOT and local agencies will continue to deploy more surveillance systems (cameras and system detectors). Additional system detectors will collect real-time vehicle volume, density and speed data to support incident detection, congestion monitoring, and congestion flow maps for travelers. The State’s major arterial roadways will include camera images and City and County operations personnel will monitor the roadways to identify and verify road and traffic conditions. Local agencies will expand network monitoring with detection systems that will be used for congestion/speed flow maps on the TripCheck website or a local traveler information website linked to TripCheck. More Cities and Counties will share viewing capabilities with ODOT and other regional partners. The state will have a common network of surveillance systems that will support managing the regional transportation network as a complete system during roadway-impacting events and traffic incidents and for displaying the information on TripCheck for traveler information.

Probe Surveillance: Probe vehicle data will be collected to provide travelers with congestion related information and predicted travel times on key arterial roadways throughout the state. The information will be displayed via a common source for traveler information regardless of roadway jurisdiction

Connected Vehicle: Transportation agencies and the automotive industry are working together on the Connected Vehicle initiative in order to reduce roadway departure and intersection crashes[24]. The following trends have led to this initiative:

- Automobile manufacturers have been installing an increasing number of sensors on vehicles for numerous functions related to safety, efficiency, and sustainability.
- The Federal Communications Commission (FCC) and the United States Department of Transportation (U.S. DOT) established a Dedicated Short Range Communications (DSRC) at 5.9 GHz to enable vehicle-to-vehicle and vehicle-to-roadside communications.
- Agencies have realized that communications between vehicles and the roadside is necessary to achieve major safety improvements.

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[24] *Concept of Operations*. ITS Joint Program Office, United States Department of Transportation. http://www.its.dot.gov/vii/vii_concept.htm. Accessed March 28, 2006.

As part of the Connected Vehicle initiative automobile manufacturers will install “on board units” (OBUs) in vehicles and transportation agencies will install “roadside units” (RSUs) at signalized intersections and at key points on urban freeways and major rural highways. The OBUs and RSUs will communicate anonymously with one another to prevent crashes. The Connected Vehicle initiative also supports the collection of probe data discussed above. These systems are still being tested.

ODOT is looking forward to the results of the testing because of the many potential benefits Connected Vehicle can provide for Oregon including the following:

- Safety Improvements: Interaction between vehicles and the roadside could greatly reduce roadway departure crashes, red-light running, and intersection collisions in Oregon.
- Probe Surveillance: ODOT could use vehicle probe data to monitor roadway mobility and road weather conditions. This information would enhance ODOT’s operational efficiency and provide additional data that can be disseminated to travelers.
- In-Vehicle Signing: ODOT could transit dynamic signing directly into the vehicle to provide information about upcoming intersections (i.e. red light ahead), work zones, variable speed limits, and so forth.
- Traffic Signal Timing Optimization: ODOT and local agencies could use vehicle probe data to support traffic responsive or dynamic traffic signal operations based on real-time traffic volumes and queuing at intersections.
- Traffic Signal Status: ODOT could use Signal Phase and Timing (SPaT) and Map Management (MAP) applications provided by the MaxConnect API through TTIP to share traffic signal lane geometry and current phase information.

Stakeholder Roles and Responsibilities

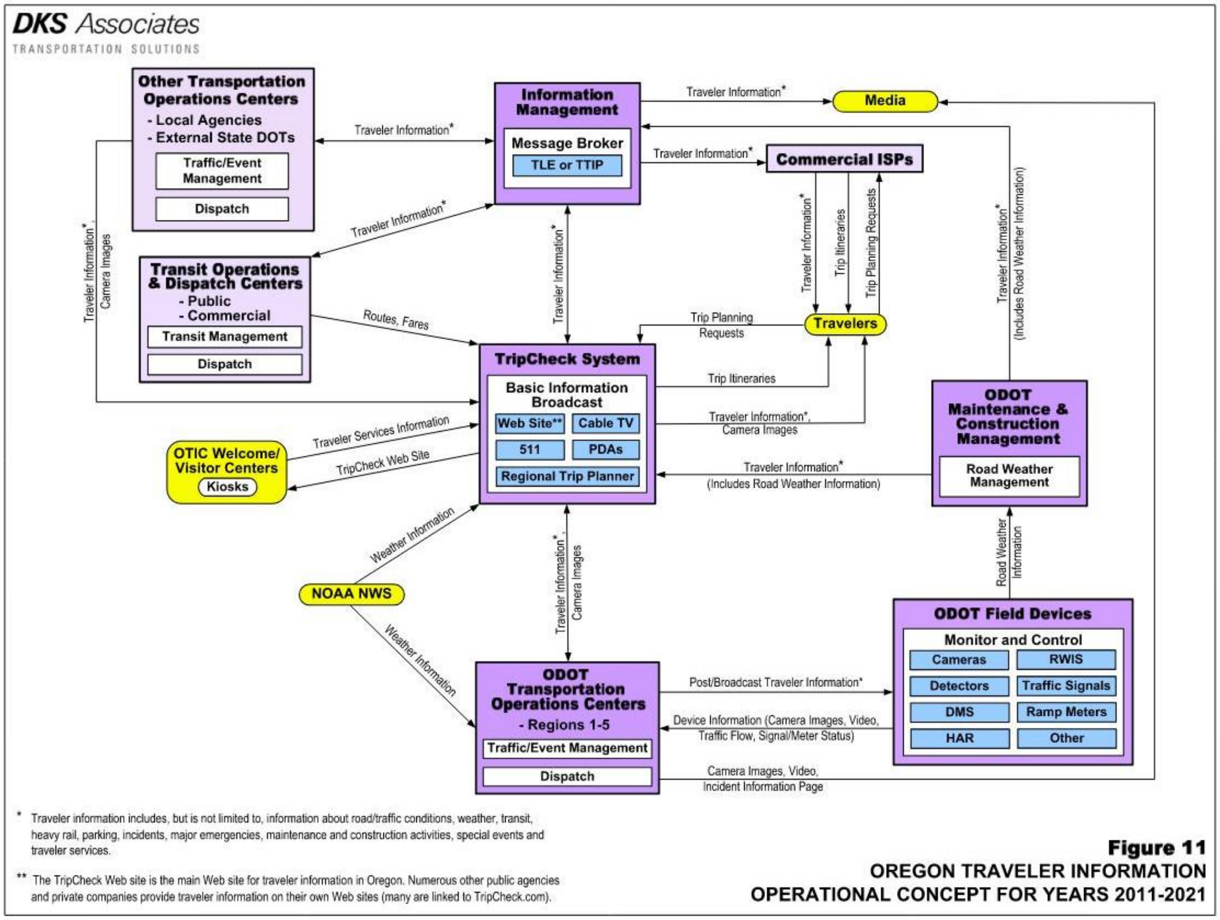
Detailed regional traffic control roles and responsibilities for key stakeholders are included in Table 11.

Table 11. Regional Traffic Control Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation	▪ Design/construct/maintain/operate surveillance and traffic control equipment on state freeways, highways and arterial roadways. ▪ Implement and operate central traffic signal systems. ▪ Design/implement/operate coordinated traffic signal timings across jurisdictional boundaries. ▪ Design/implement/operate ramp meter timings and coordination with surface street traffic signals. ▪ Share traffic control actions with other agencies. ▪ Share real-time traffic information and device control (as applicable) with Local TOCs and External State TOCs. ▪ Contribute to regional and interstate traffic control planning. ▪ Establish cooperative agreements for local and regional traffic management. ▪ Deploy RSUs at traffic signals and on key highways for Connected Vehicle.	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Future ▪ Existing ▪ Future
Local Traffic Management Agencies	▪ Design/construct/maintain/operate surveillance and traffic control equipment on arterial roadways. ▪ Implement and operate central traffic signal systems. ▪ Design/implement/operate coordinated traffic signal timings across jurisdictional boundaries. ▪ Share real-time traffic information and device control (as applicable) with other Local and ODOT TOCs. ▪ Contribute to regional traffic control planning. ▪ Establish cooperative agreements for local and regional traffic management. ▪ Deploy RSUs at traffic signals and on key highways for Connected Vehicle.	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing ▪ Existing ▪ Future
External State Departments of Transportation	▪ Share real-time traffic information and device control (as applicable) with ODOT TOCs. ▪ Contribute to interstate traffic control planning.	▪ Existing/Future ▪ Existing/Future
Heavy Rail Service Providers	▪ Share information (e.g. train arrivals/interaction with at-grade crossings) with TOCs.	▪ Future
Public Transportation Service Providers	▪ Provide transit operation status, incident, parking, and transfer operational information to TTIP, where ODOT and local traffic management agencies may access the information.	▪ Planned
Auto Manufacturers	▪ Deploy OBUs in all new vehicles for Connected Vehicle.	▪ Future
Travelers	▪ Provide personal vehicle/device probe data.	▪ Future

Traveler Information Operational Concept

Public agencies and the private sector coordinate to collect and disseminate static and real-time traveler information to Oregon travelers primarily using the TripCheck system, which is also supplemented by field devices and systems linked to TripCheck. This traveler information section includes the vision, current applications, current issues, future applications, and stakeholder roles and responsibilities. generally depicts the Oregon traveler information operational concept.



* Traveler information includes, but is not limited to, information about road/traffic conditions, weather, transit, heavy rail, parking, incidents, major emergencies, maintenance and construction activities, special events and traveler services.

** The TripCheck Web site is the main Web site for traveler information in Oregon. Numerous other public agencies and private companies provide traveler information on their own Web sites (many are linked to TripCheck.com).

Figure 11. Oregon Traveler Information Operational Concept for Years 2011 - 2021

Traveler Information Vision

The vision for traveler information is to use the TripCheck system as a comprehensive source for all static and real-time multi-modal traveler information in Oregon that allows travelers to make informed choices about mode, route, trip time, and services. Goals that support this vision include the following:

- Market the TripCheck system brand statewide and disseminate traveler information using multiple formats such as the Internet, social media, kiosks, 511 phone system, portable digital devices, cable television system, highway advisory radio, dynamic message signs (along roadway and at transit stations/stops), in-vehicle systems, and fleet systems.

- Establish partnerships with public agencies and the private sector throughout Oregon and for targeted areas in neighboring states.
- Gather information from multiple public and private sources.
- Expand the quality and reach of traveler information.
- Customize information to provide each traveler with accurate, timely information at opportune times to support their individual travel decisions.
- Provide information to public and private subscribers from one common standards-based portal on a non-exclusive basis.
- Provide a trip planner on the TripCheck website that allows for interactive multi-modal trip planning in Oregon and Washington.
- Work with neighboring states to post information that impacts interstate travelers on dynamic message signs.

Traveler Information Applications Today

Currently the primary source for roadway traveler information in Oregon is ODOT's TripCheck traveler information system, which is supplemented by field devices and other traveler information systems. The TripCheck system is operated by ODOT and also includes traveler information provided by numerous partners. The TripCheck system currently includes the following components, which are described in more detail in this section:

- Award-winning website (www.tripcheck.com)
- TripCheck Mobile
- TripCheck Twitter feed
- TripCheck Traveler Information Portal (TTIP)
- TripCheck Local Entry (TLE)
- TripCheck 511 telephone system
- Cable television broadcasts (TripCheck TV)

TripCheck Website

Of all the components the TripCheck website, launched in 2000, provides the most comprehensive source of information. The website is navigable by the following tabs, which each feature a subset of tabs with interactive maps (state, regional, and major cities) and clickable icons:

- **Road/Weather Tab:** This tab includes camera images (with an option for setting up a customized view of up to 10 cameras), road closure and delay advisories, general information, weather station data, NOAA forecasts, weather hazards/warnings, winter travel information, construction information, truck restrictions, trucking center locations, trucking Web site links, and links to neighboring state's traveler information websites. This tab includes a congestion/speed flow map of the Portland metropolitan area. This tab also allows travelers to sign up for the TripCheck Twitter feed, which is discussed in an upcoming section.
- **Travel Center Tab:** This tab includes traveler services (lodging/camping/RV, food, fuel, attractions), tourism links, rest areas, sno-parks, scenic byways, and a mileage calculator.
- **Transportation Options Tab:** This tab includes intercity transit routes, links to transit and dial-a-ride providers throughout the state, rideshare links, airport locations and links, and bicycle links.

TripCheck Mobile

TripCheck Mobile is a website formatted specifically for mobile devices (e.g. various smart phones). It uses a simple menu structure formatted for navigation by mobile keypads. TripCheck Mobile presents the same real-time travel condition information found on the TripCheck website; however, some static information (e.g. rest areas) is not presented in mobile format since the target audience is travelers making en-route decisions.

TripCheck Twitter Feed

ODOT has tailored the real-time travel condition information from the TripCheck system so that subscribers can receive it through Twitter feeds. Subscribers can choose to receive text messages from TripCheck through a variety of mediums (mobile devices, RSS feeds, and twitter.com) for selected cities, mountain passes, or specific highways throughout Oregon. The Twitter alerts provide travelers with information to make pre-trip and en-route travel decisions.

TripCheck Traveler Information Portal (TTIP)

ODOT developed a centralized web-enabled clearinghouse for statewide and Portland region traveler information called the TripCheck Traveler Information Portal (TTIP)[25]. The clearinghouse collects traveler information from multiple sources, and provides a data portal to subscribers, formatting the consolidated data as standardized traveler information messages and internally in graphical presentations. It enables the sharing of real-time information from multiple sources to any subscriber who is interested in the current status of the roadway system. This centralized system provides a “one-stop shopping center” for all traveler information including all modes. Multiple providers (public and private) have non-exclusive access to the information free of charge and can tailor it for their uses.

TripCheck Local Entry (TLE)

ODOT developed a TripCheck Local Entry (TLE) tool that allows local agencies to input information about their roadway network to the TripCheck system. Inputs include:

- Type of Event: bridge opening, construction, crash, emergency response, flooding, inclement weather, maintenance, obstruction, or planned event
- Impact: information, minimal delays, or substantial delays
- Direction of Travel
- Date and Time
- Traffic Control: bicycles on road, bus only, crowds of people, detour, flagger, height restriction, lanes closed, no through traffic, none, runners on road, sidewalk closed, speed restriction, traffic flow change, unknown, weight restriction
- Published Information: optional field that allows agencies to provide additional information about the event

The data input into TLE is transmitted to both the TripCheck system and TTIP. Local agencies are just now starting to use TLE and ODOT plans to promote this tool statewide.

TripCheck 511 Telephone System

The 511 telephone system is accessible throughout Oregon from any telephone and provides users with the travel condition information from the TripCheck system. In 2001 the Federal Communications Commission designated 511 as the single travel information phone number for

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[25] *TransPort Advanced Traveler Information Implementation Concept of Operations, Release 4 Final*. Oregon Department of Transportation, ITS Unit, 2005.

use throughout the country. The 511 system provides users with the ability to use voice recognition and the system includes eight main menu options:

1. Road conditions by highway
2. Road conditions in mountain passes
3. Road conditions in major cities
4. Commercial vehicle restrictions
5. Chain requirements
6. Road condition phone numbers for bordering states
7. Information about TripCheck 511 telephone system
8. Alerts review

TripCheck TV

ODOT provides TripCheck travel condition information and camera images to a number of cable television companies throughout the state. Each company displays the information in different formats and some provide full-motion video from ODOT's cameras.

Other Traveler Information Applications

In addition to the TripCheck system, other traveler information applications in use today include the following:

- **Dynamic Message Signs (DMSs):** Operators at ODOT, local, and neighboring state Transportation Operations Centers (TOCs) post information to DMSs along the roadway. This information includes road/traffic conditions (e.g. incidents, lane/road closures, work zones, alternate routes) and weather conditions. Agencies coordinate across jurisdictional boundaries for message posting when appropriate. For example, ODOT coordinates with WSDOT when lane closures on Interstate 5 or 205 impact interstate travel. Transit agencies post real-time arrival information to DMSs located at transit stations and stops.
- **Highway Advisory Radio (HAR):** ODOT operates one HAR station on Siskiyou Pass on I-5 providing highway advisories and traveler information. The Port of Portland is the only other agency within the State to operate a radio specifically for traveler information; they broadcast information at the Portland International Airport. In addition, there are 27 other general information service radios operating in Oregon, including nine operated by cities and counties which may be used to provide traveler information.
- **Kiosks:** The Oregon Travel Information Council and various Visitor Associations operate kiosks throughout the state at locations such as welcome/visitor centers, airports, and national/state parks that allow travelers live Internet access to the TripCheck website.
- **Telephone Systems:** A number of agencies provide static recorded information over the telephone or allow travelers to speak with operators. TriMet provides both static and real-time transit information through their transit tracker phone system.
- **Public Agency Websites:** Many public agencies post traveler information on their own websites. Most post static information (e.g. parking, construction schedules, bicycle and pedestrian facilities) but some also post real-time information (e.g. Port of Portland parking availability, TriMet transit vehicle arrivals). Many websites include a link to the TripCheck website.
- **Private Sector Websites:** The private sector provides traveler information to varying degrees. Some merely include a link to the TripCheck website while others post information from TTIP (e.g. www.trafficgauge.com and www.beatthetraffic.com) or their own sources. Some news websites in the Portland area include streaming public agency video.

- **Media Broadcasts:** The media provides traveler information via radio and television broadcasts. Some television companies provide live streaming video feed from public agency cameras or their own cameras during news broadcasts. Some of the media video feeds provide general aerial views of roadways from a helicopter or on-site images from an incident.

Traveler Information Issues

Uninformed travelers make inefficient transportation choices, which places a greater strain on the transportation infrastructure. Current traveler information issues in Oregon include the following:

- There is a lack of roadway condition, weather, incident, and maintenance/construction activity information about ODOT arterial roadways and local agency roadways (e.g. County, City, Port). Information about ODOT state highways is the most readily available today. This lack of information is in part due to limited ITS applications in existence as well as a lack of communications or systems integration to provide information to the TripCheck system.
- Travelers are frustrated by the lack of timely information as it relates to their specific travel plans. For example, a driver on the freeway impacted by an incident wants to know if it will take 10 minutes or two hours to get to their destination and whether or not there is an alternate route that will reduce their overall travel time.
- Travelers in large urban areas (e.g. Portland, Salem-Keizer, Eugene-Springfield, Bend, and Medford) need to know how traffic is flowing in order to plan their trips, particularly during the peak periods, so they may avoid congestion. The Portland freeway speed map on the TripCheck website needs to be expanded to include major arterial roadways. Speed maps for the other large urban areas need to be added to the TripCheck website. Raw speed data also needs to be added to TTIP for use by commercial ISPs.
- Special event information needs to be added to the TripCheck system using the TLE tool. For example, pre-trip and en-route information about University of Oregon football games in Eugene and Oregon State University football games in Corvallis would help travelers avoid congestion along Interstate 5 and near the football stadiums. Travelers often add to the congestion when they are uninformed about their travel options to and from the event or in the vicinity of the event.

Traveler Information Applications Tomorrow

The Oregon traveler information applications of tomorrow will address the issues described in the previous section and will include the following:

- **TripCheck Local Entry:** Partnerships will be the key to ensuring that TripCheck is the most comprehensive statewide source for traveler information. The next steps include promoting the use of TLE for public agencies to share their information with TripCheck and TTIP. This will broaden the information currently available and provide more detailed and localized road/weather conditions information from local traffic management agencies and special event information from multiple sources.
- **Increased Data Collection:** Regional ITS plans currently include planned projects for the deployment of public agency systems or devices that will increase the amount of information that may be provided to travelers. These planned projects include central traffic signal systems, system detectors, cameras, weather stations, and bus/vehicle probes on highways and major arterial roadways. This will provide more data that can be posted to TTIP and the TripCheck system and will also allow for the development of congestion/speed flow maps of large urban areas (e.g. Salem-Keizer, Eugene-

Springfield, Bend, Medford, Corvallis, Albany). This data can also be used to monitor travel times on highways and arterial roadways and to make this information available to travelers.

- **Widespread Travel Time Information Availability:** Real–time and predicted travel times will be available for highways and arterial roadways across the state to allow travelers to make informed travel decisions regarding route selection, mode selection, and optimal times for making trips. An extensive archive of historic travel time data will support the prediction of travel times.
- **Personal and In-Vehicle Devices:** The Connected Vehicle initiative is exploring options for communicating traveler specific information between vehicles and the roadside. The vision for the future is for public agencies or the private sector to tailor information from TTIP to systems on personal and in-vehicle devices based on the location of the traveler. For example, a traveler heading westbound on Interstate 84 from Boise to Baker City may receive an alert from their in-vehicle system as they approach Fruitland, Idaho to direct them to an alternate route through Fruitland because of an incident blocking all lanes of the Snake River Bridge on the Oregon-Idaho border. The widespread use of personal and in-vehicle devices may reduce the need for public agencies to install expensive roadside equipment (e.g. DMS, HAR) and focus on data collection instead.

Stakeholder Roles and Responsibilities

Table 12 includes the detailed traveler information roles and responsibilities of key stakeholders.

Table 12. Traveler Information* Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation	▪ Design/construct/maintain/operate ITS equipment to support traveler information* (e.g. cameras, system detectors, dynamic message signs, weather stations). ▪ Manage TripCheck system and disseminate traveler information* through the system. ▪ Manage TripCheck Traveler Information Portal (TTIP) infrastructure and disseminate traveler information* through the system. ▪ Manage commercial information service provider and other subscriber access to TTIP. ▪ Maintain/operate interface between the TripCheck system and TTIP. ▪ Maintain/operate TLE and interface to the TripCheck system and TTIP. ▪ Monitor direction of traveler information industry and tailor traveler information* for devices most commonly used by the public.	▪ Existing/Planned ▪ Existing/Programmed ▪ Existing/ Programmed ▪ Existing/ Programmed ▪ Existing ▪ Existing ▪ Future
Local Traffic Management Agencies	▪ Design/construct/maintain/operate ITS equipment to support traveler information* (e.g. cameras, system detectors, dynamic message signs). ▪ Provide traveler information* to TLE. ▪ Disseminate traveler information* through local systems (e.g. local websites).	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned

Stakeholder	Roles and Responsibilities	Status
External State Departments of Transportation	▪ Design/construct/maintain/operate ITS equipment to support traveler information* (e.g. cameras, system detectors, dynamic message signs, weather stations). ▪ Provide traveler information* to TLE. ▪ Disseminate traveler information* through external state systems (e.g. state websites).	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned
Public Transportation Service Providers	▪ Design/construct/maintain/operate ITS equipment to support transit traveler information (e.g. transit arrival signs, on-board systems). ▪ Provide transit traveler information (e.g. routes,schedules, special accommodations, fares) to the TripCheck system for Transportation Options. ▪ Create/maintain open GTFS data. ▪ Provide transit vehicle location information to TTIP. ▪ Disseminate transit traveler information through public transportation agency systems (e.g. transit websites and phone systems) and commercial information service providers. ▪ Develop and maintain a statewide ridesharing system (website and phone system).	▪ Existing/Planned ▪ Planned ▪ Existing/Planned ▪ Future ▪ Existing/Planned ▪ Planned
Commercial Transportation Service Providers	▪ Provide transit traveler information (e.g. routes, schedules, special accommodations) to the TripCheck system for Transportation Options. ▪ Provide transit vehicle location information to TTIP. ▪ Disseminate traveler information through commercial transportation company systems (e.g. websites) and commercial information service providers. ▪ Create/maintain open GTFS data.	▪ Existing ▪ Planned ▪ Existing/Planned ▪ Existing/Planned
Heavy Rail Service Providers	▪ Provide rail information (e.g. train location, maintenance and construction activities) to TTIP and TLE.	▪ Future
NOAA	▪ Provide weather information to the ODOT TOCs and TripCheck system.	▪ Existing
Oregon Travel Information Council	▪ Operate traveler information kiosks, which access the TripCheck website, at State Welcome Centers. ▪ Provide traveler services information (e.g. fuel, dining, lodging, tourist attractions) to the TripCheck system.	▪ Existing ▪ Existing
Visitor Associations	▪ Operate traveler information kiosks, which access the TripCheck website, at strategic locations (e.g. national/state parks, visitor centers, airports).	▪ Existing/Planned
Commercial Information Service Providers	▪ Subscribe to TTIP to obtain current real-time traveler information*. Use public transportation GTFS data to provide transit traveler information to wider audience.	▪ Existing/Planned

Stakeholder	Roles and Responsibilities	Status
	▪ Disseminate traveler information* through commercial systems (e.g. websites).	▪ Existing/Planned
Media	▪ Subscribe to TTIP to obtain current real-time traveler information*. ▪ Disseminate traveler information* through the media (e.g. television and radio broadcasts).	▪ Existing/Planned ▪ Existing/Planned
Event Promoters	▪ Provide special event information to transportation service providers, ODOT, and local traffic management agencies.	▪ Existing/Planned

* Traveler information includes, but is not limited to, information about road/traffic conditions, weather, transit, heavy rail, parking, incidents, major emergencies, maintenance and construction activities, special events, and traveler services.

Maintenance and Construction Operations Operational Concept

Public agencies and private utility companies throughout Oregon conduct maintenance and construction activities on a day-to-day basis to monitor, operate, maintain, or manage the physical condition of the roadway or other assets. The maintenance and construction operations service area focuses on these activities. This section provides a summary of the vision, current applications, current issues, future applications, and stakeholder roles and responsibilities for maintenance and construction operations. Figure 12 illustrates the operational concept for maintenance and construction operations. Although road weather condition monitoring is a maintenance function, the operational concept for road weather operations is covered in the section on road weather operations.

Maintenance and Construction Operations Vision

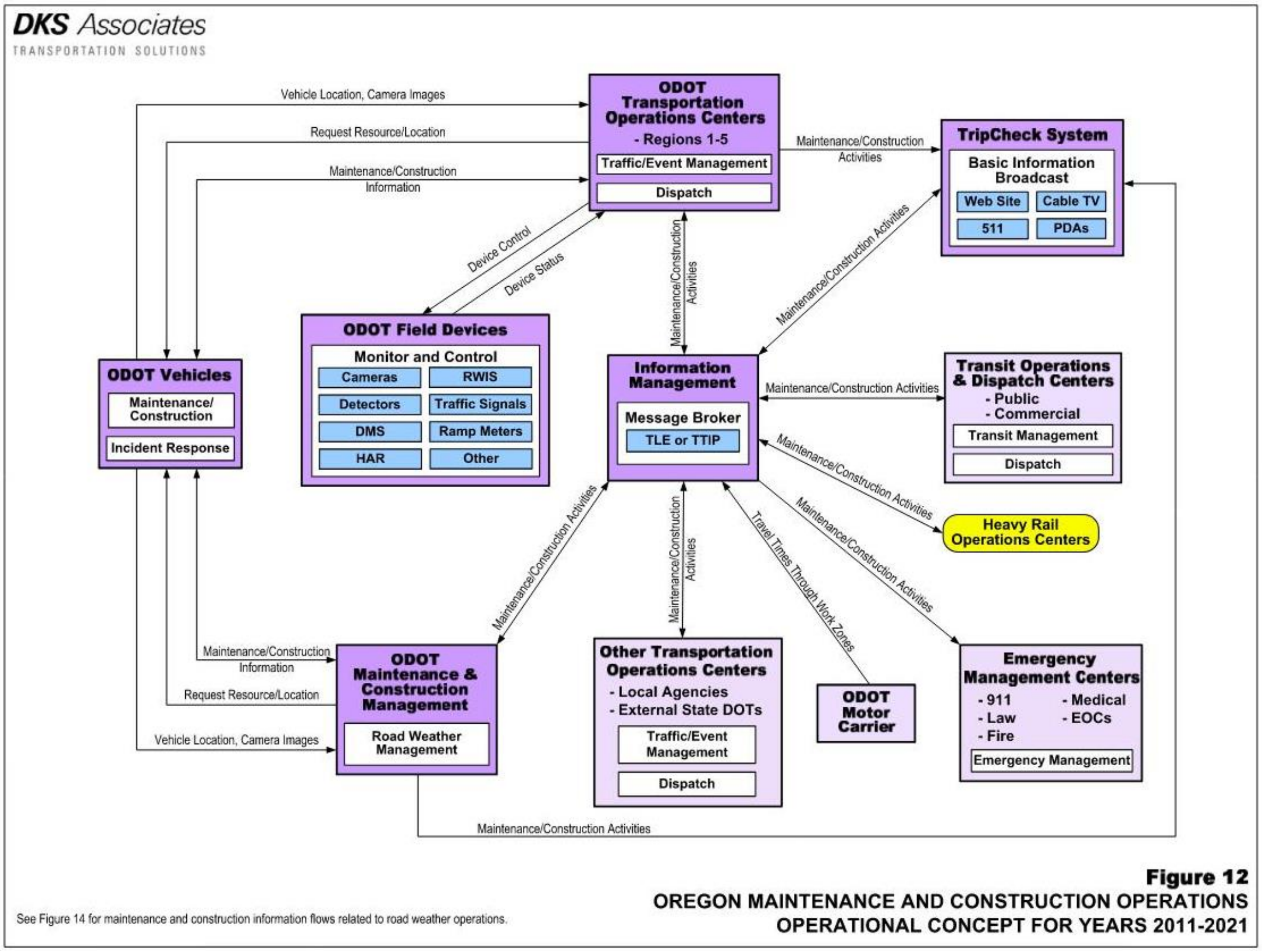
The statewide vision of maintenance and construction operations in Oregon is to enhance efficiency and coordination while also improving safety. The following goals support this vision:

- Improve work zone safety for travelers and workers.
- Provide mobility by maintaining east-west and north-south routes for people and goods traveling within Oregon or to adjacent states.
- Inform travelers of maintenance and construction activities and anticipated travel times.
- Automate maintenance and construction monitoring and activities to improve efficiency.
- Streamline and automate asset management.
- Monitor the performance measures of maintenance and construction activities, including travel delays in work zones.
- Reduce the cost of operating and maintaining transportation facilities and services.
- Efficiently report maintenance and construction activities statewide using a central system.
- Establish partnerships with public agencies and private sector utility companies throughout Oregon.

Maintenance and Construction Operations Applications Today

Limited ITS applications are used today throughout Oregon for the maintenance and construction operations service area although this area is slowly expanding as technology advances. Current maintenance applications include the following:

- **InView:** ODOT District maintenance offices use InView, which is an Intranet application linked to TOCS. It allows maintenance managers to input maintenance and construction activities, track resources, view incident details from TOCS, and run reports on TOCS data.
- **Equipment Feedback/Alerts:** Some traffic signals and ITS field devices provide alerts when non-routine maintenance is needed. For example, a traffic signal connected to a central signal system sends out an alarm when a detector loop fails.
- **Asset Management System:** Street sweeper crews in the City of Salem use handheld global positioning system (GPS) devices during routine cleaning to log items such as potholes or downed signs that require maintenance. Once back at the operations center they download this information onto a maintenance system that automatically generates work orders.
- **Fleet Management System:** TriMet uses fleet maintenance management to a limited degree. They use Bluetooth communications to read maintenance data status codes on their rail vehicles on a periodic basis to assess maintenance needs. They also use an automated system to monitor fluids at the fuel rack and to retrieve data from controllers in the engines.



See Figure 14 for maintenance and construction information flows related to road weather operations.

Figure 12
OREGON MAINTENANCE AND CONSTRUCTION OPERATIONS
OPERATIONAL CONCEPT FOR YEARS 2011-2021

Figure 12. Oregon Maintenance and Construction Operations Operational Concept for Years 2011 - 2021

The following work zone ITS elements are used in construction applications today:

- **Portable Variable Message Signs (PVMSs):** A number of agencies use PVMSs to provide warning messages or advance notification of closures and delays.
- **CCTV Cameras:** Agencies use CCTV cameras for monitoring work zones on significant road construction projects.
- **Variable Speed Limit Signs:** ODOT has used variable speed limit signs supplemented with police enforcement on a number of projects.
- **Over-Dimension Warning Systems:** ODOT has used both over-height and over-length warning systems that detect over-dimension vehicles and provide a warning (e.g. dynamic message sign or static sign with flashing beacons) for over-dimension vehicles to detour to an alternate route.
- **Traffic Management Plans (TMPs):** The Oregon Bridge Delivery Partners, who are under contract to ODOT to manage bridge construction projects on the state highway system, and ODOT require the development of TMPs for construction projects with large impacts on mobility. The goal of the TMPs is to address the traffic-related impacts of construction projects in a cost-effective and timely manner while minimally impacting mobility. These TMPs include strategies for using ITS applications to provide construction traveler information using some of the applications listed above and the TripCheck system.

Maintenance and Construction Operations Issues

The maintenance and construction operations service area faces the following issues today:

- Until now there was not a central source for all current and planned maintenance and construction activity information throughout Oregon. This has hampered coordination efforts and made it difficult to identify active construction projects on potential detour routes, particularly when a detour is needed immediately on a local agency facility due to a major incident on the state highway system.The new challenge is to convince local agencies and utility companies to input their maintenance and construction activities into TLE.
- Numerous maintenance activities are conducted manually today such as asset management and fleet management. This makes it harder to track when to conduct preventative maintenance.
- Many construction projects restrict heavy, wide, or tall commercial vehicles resulting in detours, which causes freight delays and negative economic impacts.
- Every year motor vehicle crashes in U.S. work zones kill an average of 1,020 persons and injure more than 40,000 people[26]. Approximately half of the fatalities occur during the day and two times as many fatalities occur on weekdays than on weekends. Eighty-five percent of the work zone fatalities are typically the drivers or passengers and the other 15 percent are the workers.
- Crashes in Oregon work zones have been on the as shown in Figure 13. On average there were approximately 530 annual work zone crashes in Oregon from Year 2005 to 2009 and these include approximately ten fatalities and 280 injuries each year.

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[26] *Work Zone Safety Facts & Statistics*. Federal Highway Administration. http://safety.fhwa.dot.gov/wz/wz_facts.htm. Accessed Aug. 24, 2005.

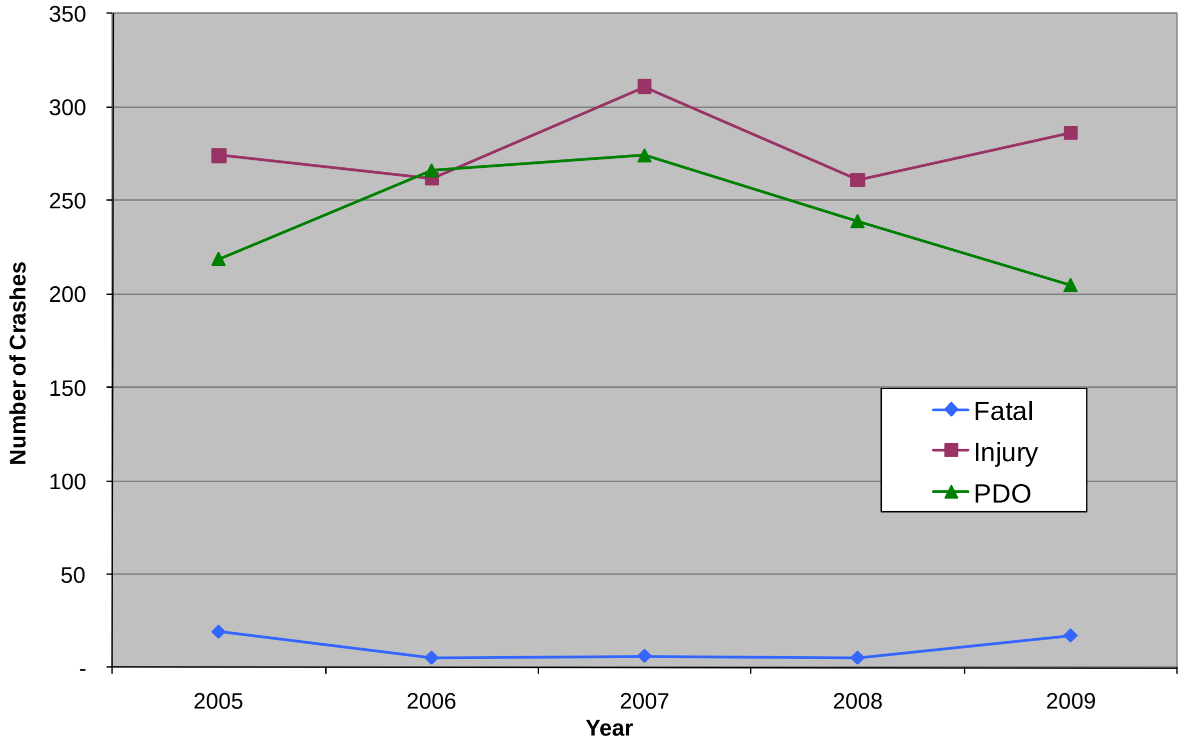

Figure 13. Oregon Crashes in Work Zones for Years 2005 to 2009[27]

Maintenance and Construction Operations Applications Tomorrow

The maintenance and construction operations of tomorrow will address current issues and will include the following applications:

- **Activity Coordination Database:** TLE and TTIP, which are described in the Traveler Information Operational Concept, will support a statewide maintenance and construction coordination system. This system will include information input by stakeholders regarding active and planned maintenance/construction, vehicular restrictions, anticipated work zone travel times, and other pertinent information. This system will help transportation managers monitor construction activities and schedules, coordinate different work on the same corridor, and ensure that there is always an open east-west route and north-south route for freight movement. Additionally, filters may be used to provide commercial information service providers with information that is ready for distribution to the public.
- **Traveler Information:** The information from the activity coordination database as well as work zone travel times (estimates based on real-time data and forecasts) will be disseminated using work zone ITS elements and the applications discussed in the Traveler Information Operational Concept section (e.g. TripCheck system and TTIP).
- **Asset Management Systems:** Asset management will be streamlined by agencies throughout Oregon using technology such as global positioning systems (GPS). Systems similar to the City of Salem's will be implemented. ODOT's ITS Support Coordinators plan to barcode ITS devices as part of their asset management strategy.

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[27] *Statewide Crashes Involving Work Zones*. Crash Analysis & Reporting Unit, Oregon Department of Transportation, December 2009.

- **Fleet Management Systems:** As technology advances agencies throughout Oregon will use fleet management systems to schedule routine vehicle maintenance and to track vehicles in the field. Although the tracking of maintenance vehicles is less critical for daily routine operations it is essential during a major emergency situation.
- **Work Zone Standards and Management Techniques:** Public agencies will develop standards and management techniques for safety enhancements such as variable speed limits, incident detection and management, lane merge controls, queue detection with electronic driver feedback signs, and intrusion detectors to alert workers of vehicles entering prohibited areas.

Stakeholder Roles and Responsibilities

Table 13 includes the key stakeholder roles and responsibilities for the maintenance and construction operations service area.

Table 13. Maintenance and Construction Operations Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation	▪ Integrate HTCRS with TOCS and TTIP. ▪ Coordinate maintenance and construction activities with local traffic management agencies, external state DOTs, public and commercial transportation service providers, and private utility companies using HTCRS/TTIP. ▪ Automate maintenance and construction activity scheduling. ▪ Track maintenance/construction vehicle location and activity throughout the state. ▪ Develop statewide standards and requirements for work zone safety. ▪ Manage work zones using cameras, dynamic message signs, highway advisory radio, and variable speed limits. Provide travelers with delay and detour information. ▪ Deploy over-dimension warning systems in work zones when over-dimension vehicles are required to detour to an alternate route. ▪ Monitor travel times through work zones and provide travel time information to the public. ▪ Deploy work zone intrusion sensors and alarms to improve safety during construction.	▪ Existing ▪ Existing ▪ Future ▪ Future ▪ Planned ▪ Existing ▪ Existing ▪ Planned ▪ Planned
Local Traffic Management Agencies	▪ Coordinate maintenance and construction activities with other public agencies (including public transportation agencies)and private utility companies using TLE and TTIP. ▪ Manage work zones using cameras, dynamic message signs, and variable speed limits. Provide travelers with delay and detour information.	▪ Planned ▪ Existing/Planned
External State Departments of Transportation	▪ Coordinate maintenance and construction activities near the state line with ODOT using TLE and TTIP.	▪ Programmed

Stakeholder	Roles and Responsibilities	Status
Heavy Rail Service Providers	▪ Coordinate maintenance and construction activities for at-grade rail crossings with public agencies and private utility companies using TLE and TTIP.	▪ Future
Public Transportation Service Providers	▪ Coordinate maintenance and construction activities with other public agencies and private utility companies using TLE and TTIP.	▪ Planned

Road Weather Operations Operational Concept

Although a subset of maintenance and construction operations, road weather operations is an important service area of public agencies in Oregon due to the transportation network impacts caused by inclement winter weather, rain, and high winds. These agencies monitor road weather conditions, track available equipment and personnel, and coordinate a response during inclement weather events. This road weather operations section includes the vision, current applications, current issues, future applications, and stakeholder roles and responsibilities. A graphical depiction of the road weather operational concept is shown in Figure 14.

Road Weather Operations Vision

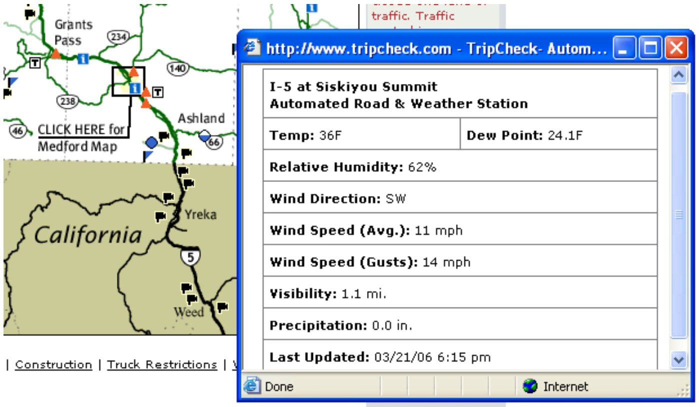
The Oregon vision for road weather operations is to efficiently and safely manage the transportation infrastructure during inclement weather events. Goals that support this vision include the following:

- Efficiently manage and schedule road weather maintenance activities statewide using a central system.
- Provide better access to and more accurate weather forecasts and pavement condition models to aid in decision making.
- Enhance mobility for people and goods traveling within Oregon or to adjacent states during inclement weather events by promoting awareness of alternate routes when roads are closed or impacted by the weather.
- Reduce the cost of operating and maintaining transportation facilities and services.
- Improve the safety of roadways typically impacted by severe weather events.
- Provide current and forecasted road and weather conditions to travelers using automated systems.

Road Weather Operations Applications Today

The following road weather operations applications are in use today:

- **Road Weather Information Systems (RWISs):** RWISs are used to varying degrees throughout the state. ODOT has deployed 79 and a limited number of public agencies (e.g. Clackamas County, Marion County, City of Keizer) have deployed their own RWISs. A typical RWIS installation measures atmospheric conditions such as temperature,



I-5 at Siskiyou Summit
Automated Road & Weather Station

Temp: 36F

Dew Point: 24.1F

Relative Humidity: 62%

Wind Direction: SW

Wind Speed (Avg.): 11 mph

Wind Speed (Gusts): 14 mph

Visibility: 1.1 mi.

Precipitation: 0.0 in.

Last Updated: 03/21/06 6:15 pm

RWIS Data on TripCheck Website

humidity, precipitation, and wind speed while more sophisticated RWIS installations may also include pavement sensors that measure surface temperature, surface condition (wet, dry, frost, snow, ice, etc.), and the freeze point of the road surface while other atmospheric sensors measure visibility distance and precipitation intensity. Information from the RWIS installations is used to more efficiently determine the appropriate operational responses (e.g. apply anti-icing strategies, activate warning systems, disseminate inclement weather information to travelers). Real-time RWIS data is also posted to the TripCheck website.

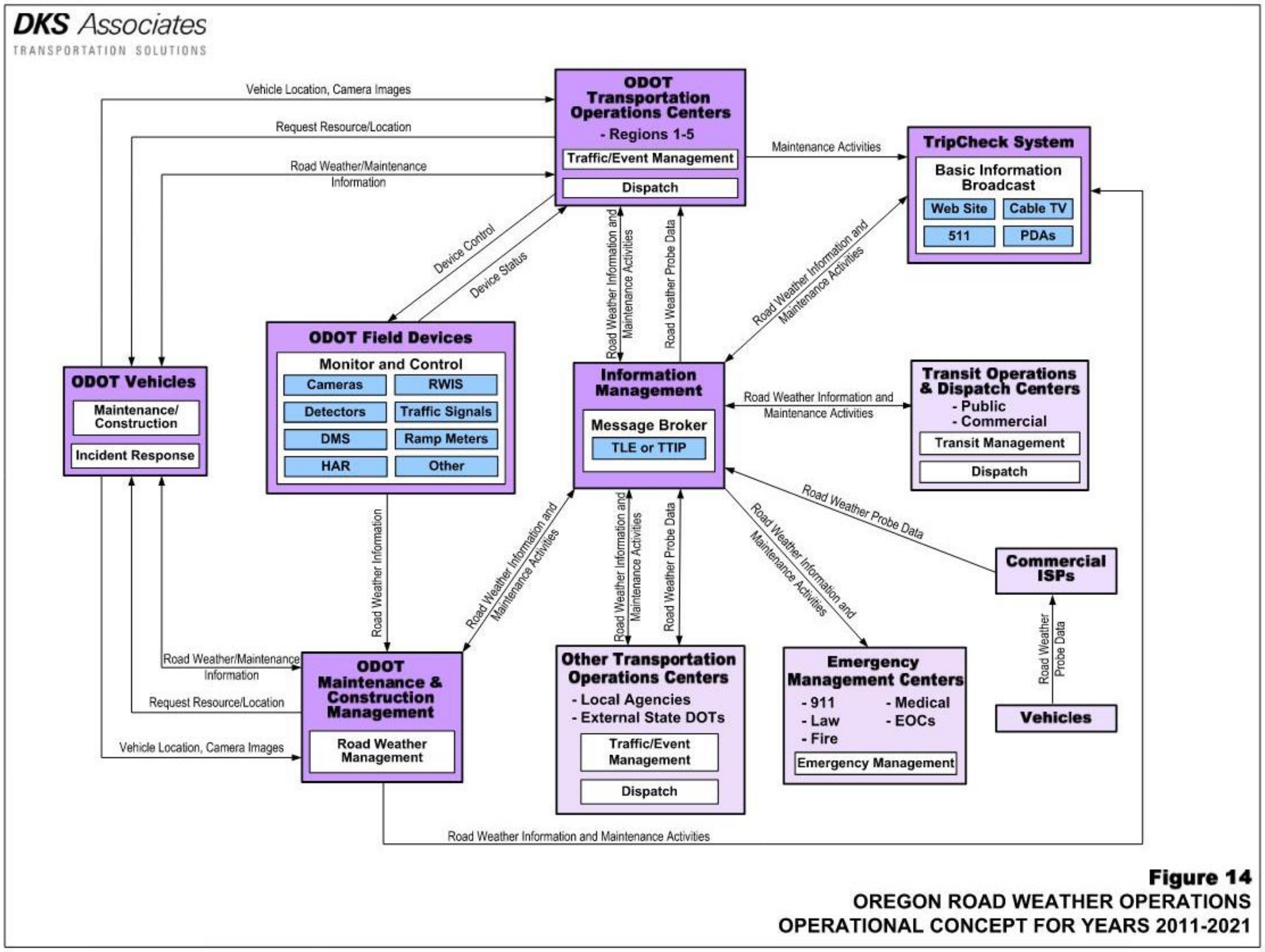


Figure 14. Road Weather Operations Operational Concept for Years 2011 - 2021

- **RWIS Web Database:** Data from ODOT's RWIS equipment is currently accessible through an intranet-accessible SCAN Web database. This includes current and historical data as well as graphic depictions of data.
- **Maintenance Kiosks:** ODOT recently installed maintenance kiosks, which include an Internet-accessible personal computer, at 64 of its maintenance stations throughout Oregon. These kiosks are linked to the RWIS Web Database, the TripCheck system, NOAA, and ODOT's digital video log. The kiosks are centrally located so that all maintenance crew personnel have access to the system.
- **RWIS Notification System:** ODOT developed a notification system that alerts subscribers via text page or e-mail for the following six conditions at a particular RWIS site: 1) Frost/Ice Alert, 2) Fog Alert, 3) Wind Speed Alert, 4) Visibility Alert, 5) Freezing Precipitation Alert, or 6) RWIS Failure Alert. The wind speed and visibility alerts are user defined and users can subscribe to any number of RWIS and alert combinations. This system could be expanded to include other agencies' RWIS sites or could be used as a model for other agencies.
- **Automated Roadway Treatment:** ODOT has several automated roadway treatment systems in place today: two heating systems that activate to prevent black ice when temperatures near the freezing point and a spray system that applies anti-icing fluid to the roadway. The technologies used in these systems have not yet proven to be reliable.

Weather Warning Systems: ODOT has deployed a number of automated or remotely controlled weather warning signs related to wind, snow, ice, or flood conditions throughout the state. This allows ODOT personnel to alert travelers of high winds, which mostly impact high-profile vehicles, or to use traction tires and/or chains in snow/ice areas. ODOT has a flood warning system on US 101 near Seaside that detects water levels on the roadway and alerts drivers about the road conditions and detours using an automated sign. Dynamic message signs, snow zone drum signs, and highway advisory radio have also been installed in strategic locations to provide this information in addition to other traveler information. These systems enable ODOT to focus on maintenance activities instead of manually updating weather information signs.

Road Weather Operations Issues

Issues that impact road weather operations today include the following:

- Winter weather in Oregon causes roadways to accumulate snow, ice, or both while melting snow and heavy rains may cause roadways to flood or become obstructed by landslides. Inclement weather often results in road closures or crashes. In 2004, approximately 22 percent of crashes in Oregon occurred during wet pavement conditions and approximately five percent occurred during snowy or icy pavement conditions[28].
- Weather and pavement conditions in remote rural areas (e.g. mountain passes) are not always available other than from the National Weather Service or other local forecasts for nearby areas. Maintenance managers could make more efficient resource decisions with better access to and more accurate local weather forecasts and pavement condition models.
- A number of warning signs related to high winds and heavy snow must still be manually rotated by maintenance crews when needed.
- Reliable technology has not yet been developed for automated roadway treatment on the state highway system. There are a number of roadway locations on bridges and

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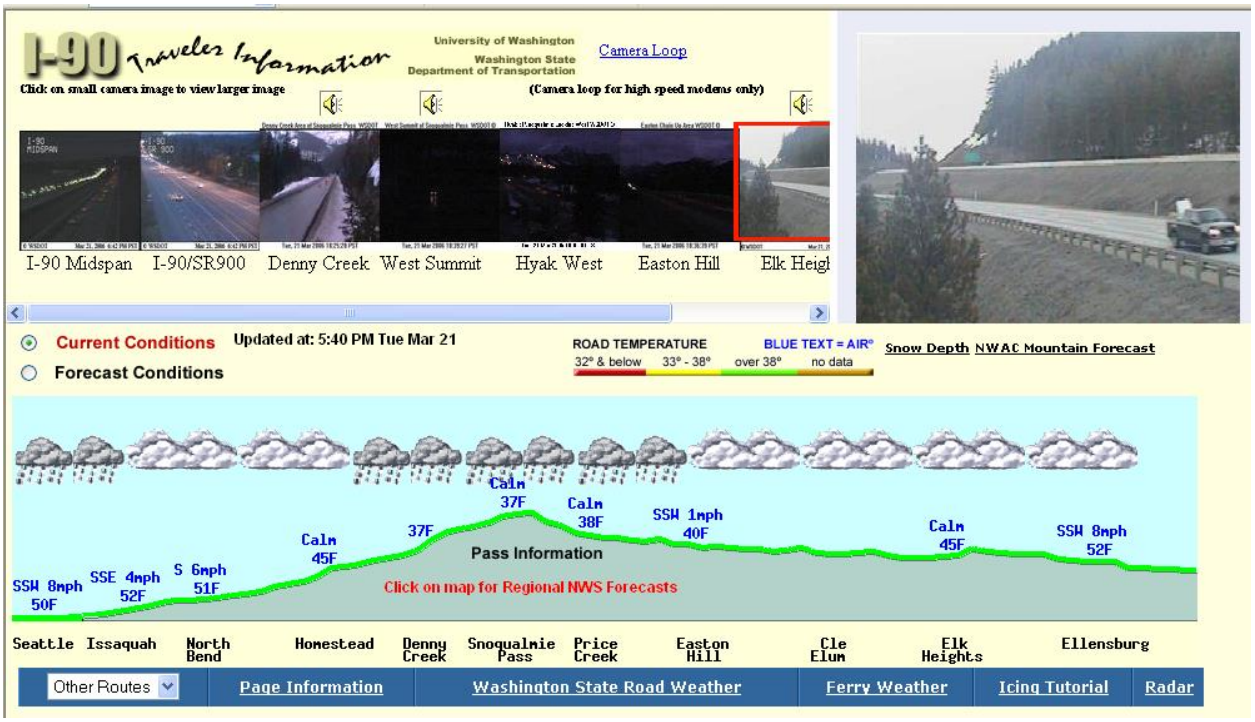
[28] *2004 Oregon Traffic Crash Summary*. Oregon Department of Transportation, Transportation Data Section, Crash Analysis and Reporting Unit, July 2005, p. 26.

mountain passes that routinely accumulate black ice and must be dealt with manually by maintenance crews.

Road Weather Operations Applications Tomorrow

The following applications of tomorrow are planned to expand the road weather operations service area and to address the current issues:

- **RWIS Expansion:** Regional ITS architectures have identified locations on ODOT, County, and City facilities throughout Oregon where RWIS stations should be installed over the next 20 years to improve the monitoring and response capabilities of maintenance personnel.
- **Automated Roadway Treatment:** Regional ITS architectures have identified locations on ODOT facilities throughout Oregon where automated roadway treatment systems should be installed to prevent the formation of black ice during winter storms. These systems should only be deployed when the technology has proven to be reliable and cost-effective.
- **Flood/Slide Warning Systems:** Clackamas and Multnomah Counties have identified a future need for flood/slide warning systems on roadways within their jurisdictions that frequently flood during heavy rains and must manually be closed.
- **Winter Traveler Information:** Future enhancements to the TripCheck website will include graphical displays of weather conditions and camera images in mountain pass areas such as the Siskiyou Pass on I-5 near the California border. These graphical displays will illustrate a profile of the pass with road temperature, current weather conditions, forecasted weather conditions, and camera images similar to the I-90 Traveler Information website shown below. Data displayed for each mountain pass will come from ODOT or other traffic management agency RWIS sites and CCTV cameras as well as from National Weather Service sources.



I-90 Traveler Information in Washington (http://www.atmos.washington.edu/maciver/roadview/i90/)

- **Weather Probes:** Many commercially available automated vehicle location (AVL) systems have a component that measures ambient conditions and provides weather information to the driver using an in-vehicle component. In addition, several use cases in the Connected Vehicle initiative describe using private vehicles as probes to gather information such as pavement temperature, friction, and the presence of rain. In the future these systems may provide public agencies with more complete weather coverage to aid in decision making and traveler information dissemination.
- **Road Weather Forecasting and Maintenance Decision Support System:** A system that uses RWIS data, weather probes, and National Weather Service forecasts to develop road weather forecasts about pavement and weather conditions along a route is a desired future application that would serve Oregon public agencies and travelers well. The U.S. DOT and NOAA are currently working on the Clarus initiative to test a system that integrates weather observing, forecasting, and data management. In addition, they are working on a winter maintenance decision support system (MDSS) that will incorporate forecast information and model various treatment options to help a maintenance manager select the right resource strategy to deal with a coming storm.
- **Weather-Based Variable Speed Limits:** Roadways will be equipped with variable speed limit signs in areas that frequently experience inclement weather. The standard posted speed limit will be lowered when warranted by weather conditions such as snow, ice, rain, heavy fog, or other conditions.
- **Automated Vehicle Location:** ODOT will use automated vehicle location technology for all of their road weather maintenance vehicles.
- **Automated Road Weather Maintenance Logs:** ODOT will keep automated logs for road weather maintenance activities such as sanding and deicing roadways. These logs will be automatically updated based on real-time information from maintenance vehicles.

Stakeholder Roles and Responsibilities

Table 14 includes the detailed road weather operations roles and responsibilities for the key stakeholders.

Table 14. Road Weather Operations Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation	▪ Design/construct/maintain/operate weather monitoring and pavement sensor systems. Areas of concern include passes, bridges, and other critical roadway sections. ▪ Share weather information with other agencies using TTIP. ▪ Design/construct/maintain/operate systems that detect adverse winter weather conditions and automatically treat the roadway when needed. ▪ Notify maintenance personnel of severe winter weather events. ▪ Automatically track maintenance vehicle location (e.g. snow plows, deicers) and activity throughout the state to support resource allocation decisions. ▪ Coordinate winter weather maintenance activities within ODOT and with other agencies using TTIP. ▪ Disseminate road weather hazard information, travel restrictions, and chain requirements to travelers (e.g. DMS, HAR, TripCheck system). ▪ Expand winter traveler information for mountain passes on the TripCheck website.	▪ Existing/Planned ▪ Existing ▪ Existing/Future ▪ Existing ▪ Future ▪ Existing ▪ Existing ▪ Planned
Local Traffic Management Agencies	▪ Design/construct/maintain/operate weather monitoring and pavement sensor systems. ▪ Share weather information with other agencies using TLE and TTIP. ▪ Coordinate winter weather maintenance activities within agency and with other agencies using TLE and TTIP.	▪ Existing/Planned ▪ Programmed ▪ Programmed
External State Departments of Transportation	▪ Design/construct/maintain/operate weather monitoring and pavement sensor systems. ▪ Share weather information with ODOT using TLE and TTIP. ▪ Coordinate winter weather maintenance activities near the state line with ODOT using TLE and TTIP.	▪ Existing ▪ Programmed ▪ Programmed
NOAA	▪ Provide weather forecasts, watches, and warnings for Oregon to TTIP.	▪ Existing

Incident Management Operational Concept

Per the ODOT Emergency Operations Plan, "Incidents may include disabled vehicles, obstacles or debris on the roadway, spilled cargo or material, motor vehicle crashes, or any other situation which affects normal traffic flow or poses a hazard to the public."29 The incident management service area includes all of the roadway subsystems, communications, and agency coordination required to quickly and accurately identify incidents and implement a response that safely minimizes incident-related impacts such as delay to people and freight and negative environmental effects. ODOT has taken a proactive approach to incident management by using their TOCs to monitor, detect, and verify incidents on state roadways, using highway service patrols to detect and respond to incidents, and by partnering with emergency management agencies to provide a coordinated response. Local traffic management agencies provide incident management on a smaller scale using their emergency management departments and maintenance crews. The incident management operational concept covers the roadway incidents that occur on a day-to-day basis while the emergency management operational concept described in the next section focuses on major emergencies. This section includes the incident management vision, current applications, current issues, future applications, and stakeholder roles and responsibilities. Figure 15 illustrates the operational concept for both incident management and emergency management.

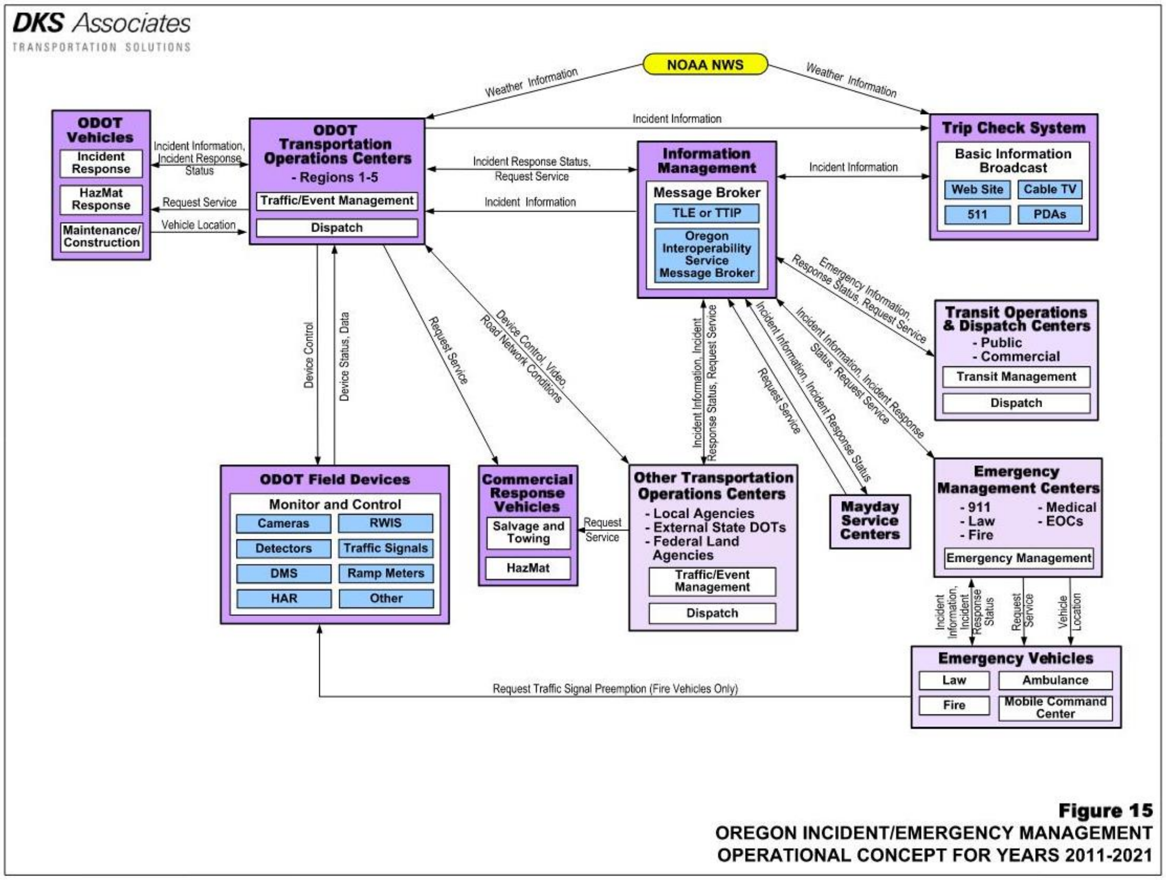


Figure 15. Oregon Incident/Emergency Management Operational Concept for Years 2011 - 2021

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[29] *Oregon Department of Transportation Emergency Operations Plan*. Revision 6. Oregon Department of Transportation, Office of Maintenance, Emergency Preparedness Committee, Feb. 2004.

Incident Management Vision

The vision for incident management is to proactively prevent, quickly detect, and enable rapid pre-planned responses to safely and efficiently manage incidents that impact the Oregon transportation system through a coordinated effort by ODOT, local traffic and transit management agencies, and emergency management agencies. The vision includes actively engaging the public to empower them with information that will enable them to avoid potential or current incidents. The following goals support this vision:

- Improve and enhance the safety and security of emergency responders, the traveling public, and the environment.
- Maximize the coverage and consistency of ODOT and local agency incident response programs.
- Improve mobility on Oregon's transportation system and reduce the economic impact caused by incident-related congestion.
- Get traffic moving (on a shoulder, single lane, or other means) within 90 minutes of a full highway closure.
- Use technology and partnerships to reduce time to detect, verify, respond, and clear incidents.
- Improve traffic management during incidents to mitigate traveler delays. This includes integrating traffic device control with incident response systems as part of TOCS.
- Develop and strengthen partnerships on state, regional, and local levels.
- Integrate systems and communications between statewide partners.
- Provide incident information and transportation system impacts to travelers in a timely manner.

Incident Management Applications Today

As described in this section ODOT and neighboring state DOTs provide comprehensive incident management services in coordination with emergency management agencies today while local traffic management agencies provide services on a more limited scale. ODOT currently uses the following incident management applications:

- **Quick Clearance Legislation (Move It Law):** Oregon law (ORS 811.717) requires drivers to move motor vehicles from the roadway if there are no apparent personal injuries, the motor vehicle is operable, and it is safe to move the vehicle.
- **Incident Detection:** ODOT uses system detectors, CCTV cameras, and input from incident responders, other agencies, and the public to detect incidents. Vehicle detector loops installed on the highway alert TOC operators when congestion is present due to preset vehicular volume thresholds. CCTV cameras are used to detect incidents during frequent monitoring as well as to verify incidents identified by system detectors or outside sources.
- **Highway Service Patrols:** Highway service patrols are one of the cornerstones of ODOT incident management. ODOT currently uses incident response vehicles in Regions 1, 2, and 4 to actively monitor, detect, and respond to incidents on the state highway system. These vehicles are equipped with flat tire repair gear, gasoline, jumper cables, water, traffic control devices, dynamic message signs, and other

ODOT Incident Response Vehicle

essentials for assisting motorists and responding to incidents. Region 1 Incident responders are also equipped with GPS units in their mobile phones so they can be tracked by TOC operators. Incident responders coordinate closely with the ODOT TOCs and emergency responders, particularly those with the Oregon State Police, local fire and life safety agencies, and emergency medical service providers.

- **Maintenance Crews:** ODOT maintenance crews perform incident response for areas without service patrols and assist with incident response activities in areas served by highway service patrols.
- **Mobile Camera Phones:** ODOT Region 2 incident responders carry mobile camera phones to transmit images taken onsite back to the TOC and other decision makers.
- **Traffic Control Devices:** In the Portland metropolitan area ODOT uses ramp meters to control the flow of traffic entering the freeway during incidents. They also have special traffic signal timing plans that may be used along the Interstate 5/Barbur Boulevard (OR 99W) and Interstate 205/82nd Avenue (OR 213) corridors during an incident. These plans favor heavier movements at traffic signals on the arterial or at interstate ramp terminals when vehicles divert from the freeway.
- **Incident Notification Paging System:** Each ODOT TOC uses a paging system to provide incident information to other stakeholders, the media, and anyone who wishes to subscribe to the system. The extent of media subscribers varies throughout the state. The system sends text messages to pagers and telephones.
- **Computer Aided Dispatch (CAD):** 911 centers and other emergency services dispatchers such as the Oregon State Police use CAD systems to dispatch emergency responders to an incident, map addresses, and provide other useful information. The Oregon Interoperability Service (OIS) was developed as a message broker that provides CAD system interoperability between various vendors' systems. It is a push only system that allows information to flow from one agency to other pre-designated agencies depending on the information type. Subscribers are not able to extract information from the broker. The OIS has been implemented in several areas of the state.
- **License Plate Checks:** Certified operators at ODOT TOCs (Regions 1 – 4) perform license plate checks on vehicles prior to ODOT contact with the driver and passengers to provide safety for incident responders and maintenance personnel. The operators use ForseCom to check the plates in Oregon's Law Enforcement Data System (LEDS) and the National Crime Information Center (NCIC) system to check for any warrants (e.g. stolen vehicle).
- **Salvage and Towing Coordination:** The ODOT TOCs dispatch salvage and towing service providers when needed. They dispatch preference tows as well as non-preference tows, which are taken from a tow rotation list maintained by the Oregon State Police. The dispatchers also contact an automobile club (e.g. AAA) if a person involved in an incident is a member of one.
- **Collision Reconstruction:** ODOT personnel assist the Oregon State Police or other police agencies with collision reconstruction when needed.
- **Alternate Route Maps:** Several ODOT publications include alternate route maps for a number of major freeways and highways throughout Oregon.
- **Incident Management Operational Plans:** ODOT and the City of Portland developed incident management operational plans for the Interstate 5/Barbur Boulevard and Interstate 205/82nd Avenue corridors in Portland that include a concept of operations that outlines each agency's roles and responsibilities (including control of the other agency's devices as appropriate) as well as specific operational scenarios for each segment of the corridor for use during an incident. As part of the plan, incident coordinated signal timing plans were developed for each of the scenarios and arterial dynamic message signs were installed at key locations along the arterials to alert drivers of detours or locations

where diverted vehicles could re-enter the interstate past the incident or once the incident is clear.

- **Traveler Information:** ODOT provides travelers with information about incidents and the impacts to the transportation network using the TripCheck system and other applications described in the Traveler Information Operational Concept.
- **Mayday Support Services:** OnStar, a General Motors service, currently provides traveler assistance via communications between a mayday service center and a personal vehicle. ODOT worked with OnStar to develop systems interfaces that allows OnStar to alert ODOT when ODOT's incident response services may be needed. Other mayday service providers may be incorporated in the future.

Emergency management agencies currently provide law enforcement, fire and life safety, and emergency medical response at incident locations when warranted by the severity of an incident. Their presence is required for any incidents that involve injuries or fatalities. Emergency responders are coordinated on-scene by an incident commander, which is typically a representative from the responding fire agency, and through call-taking and dispatch centers (911 centers, Oregon State Police dispatch centers, other emergency management agency dispatch centers, ODOT TOCs, and neighboring state TOCs).

In particular, the Oregon State Police (OSP) work closely with ODOT to provide incident management services. In several locations ODOT TOCs are co-located with OSP dispatch centers allowing the two agencies to communicate and coordinate directly during an incident and to share resources (e.g. streaming video).

The Departments of Transportation (DOTs) in neighboring states manage incidents on their state highway systems using similar applications as ODOT to varying extents. Their TOCs coordinate with ODOT TOCs when incidents occur at or near the state border or impact interstate travel.

Local traffic management agencies respond to incidents on their roadways using maintenance vehicles/crews and local emergency management agencies on an as-needed basis. For example, a citizen may call an agency about road debris on a busy arterial roadway and a County or City agency may send a maintenance crew to remove the debris. Similarly, if there is a major incident on a key roadway the police or fire personnel on-scene may request aid (e.g. placement of cones/barrels, route diversion signs) from the appropriate County or City agency. Multnomah County recently acquired three incident response vehicles that they are using on an as-needed basis.

Incident Management Issues

The following issues affect incident management today:

- In 2007, congestion caused urban Americans to travel 4.2 billion hours more and to purchase an extra 2.8 billion gallons of fuel for a congestion cost of $87.2 billion – an increase of more than 50 percent over the previous decade.[30]
- Figure 16 depicts the number of statewide traffic impacting incidents in Oregon from October 2009 through September 2010 and the average incident duration in minutes. Incident duration is measured from the time an incident is detected until the time ODOT leaves the scene. During this timeframe, the greatest number of incidents occurred in December, followed by the summer months (July, August and September). December

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[30] *Urban Mobility Report 2009.* Texas Transportation Institute.

and October both averaged the highest incident duration times of approximately 160 minutes. During the other months of the year the average incident duration times were generally below 100 minutes.

- A number of detour routes have been identified for the interstate system, select state highways, and other major roadways. However, these routes have not been evaluated to determine if existing ITS applications may be used to support diversions during major incidents or if additional ITS applications are needed (e.g. changeable fixed message signs, system detectors, CCTV cameras, coordinated incident signal timing plans). Additionally, pre-defined detour routes have not been identified on a number of major travel and freight corridors throughout Oregon.
- Although most agencies provide incident training to their own personnel, there is a lack of cross-agency drills, training, or tabletop discussions. This sometimes reduces the efficiency of incident response, which in turn increases traveler delay. For example, sometimes incident and emergency vehicles block more travel lanes than is necessary for a response and that creates an additional bottleneck at the incident location.

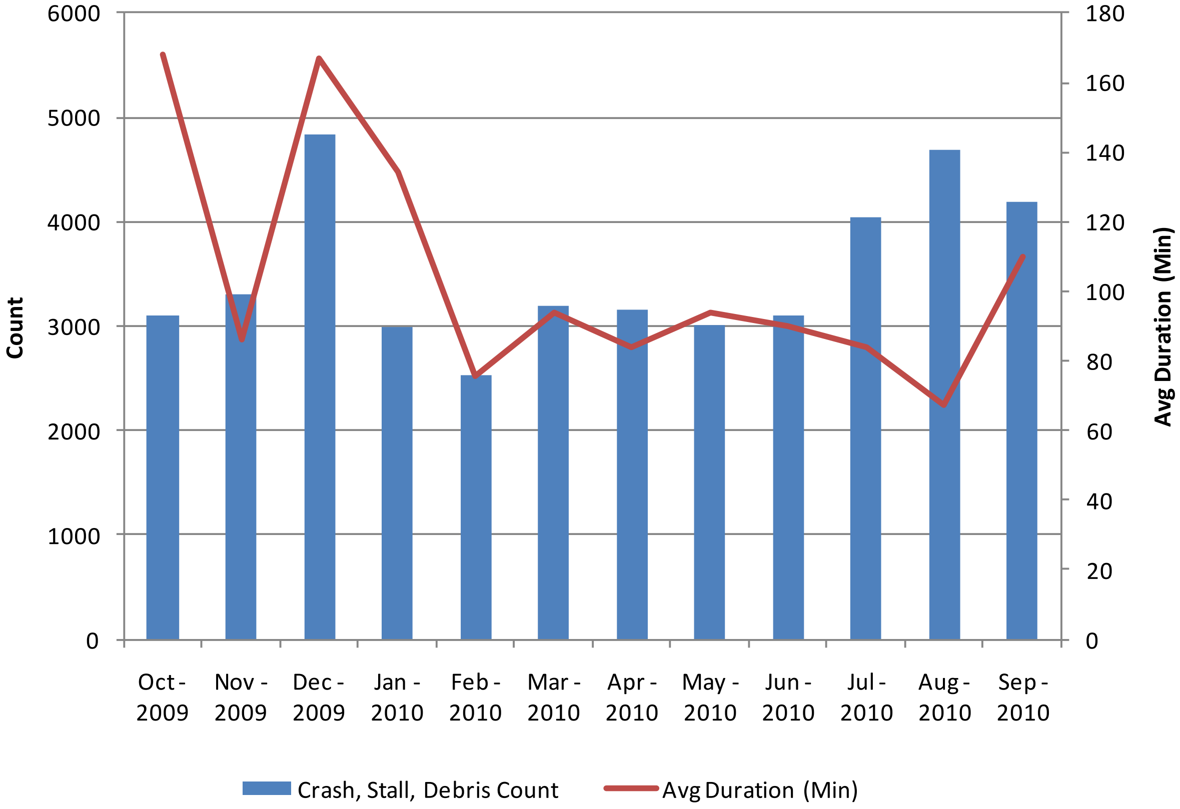

Figure 16. Oregon Statewide Traffic Impacting Incidents and Clearance Times for October 2009 through September 2010

Incident Management Applications Tomorrow

The following incident applications will be implemented tomorrow to expand existing systems and address current issues:

- **Incident Response Programs:** Incident response programs will be expanded or developed to address congestion on ODOT's arterial roadways in urban areas and on local agency arterial roadways.
- **Oregon Interoperability Service Expansion:** The OIS may be expanded to a statewide level or may be duplicated in other regions to provide a seamless interface between key incident and emergency management agencies.
- **Incident Management Operational Plans:** ODOT and local traffic management agencies will develop incident management operational plans for key roadways that frequently experience incident-related lane reductions or closures. These plans will include existing practices and procedures, roles and responsibilities, description of existing ITS applications, identification of ITS applications needed to improve operations, criteria for system activation, and operational scenarios. The operational scenarios should include maps and procedures for device control and placement such as CCTV camera utilization, messages to post on DMS, use of portable DMS if necessary, ramp closures, and implementation of traffic signal timing plans. TOCS will include an alternate route planning tool, which will allow ODOT to input the components of these incident management operational plans that can be automatically implemented by TOCS based on actual incident conditions.
- **Training:** TOCS will include a simulation for conducting incident drills. Used within ODOT and in coordination with other incident response partners this will improve the efficiency of incident response.

Other states have implemented a number of innovative incident management policies, laws, practices, and technologies that may be applicable to the Oregon transportation system such as:

- Quick clearance legislation
- Quick clearance static signage for motorists
- Emergency reference markers every 2/10th mile
- On-call maintenance volunteers
- Accident investigation sites
- Heavy vehicle identification guides
- Heavy vehicle recovery equipment
- Automated debris recovery systems
- Median cross-over plans for emergency vehicles
- Photogrammetry
- Ambulance-hospital information systems
- Incident record databases
- Inter-agency cross-training

Stakeholder Roles and Responsibilities

Detailed incident management roles and responsibilities for key stakeholders are included in Table 15.

Table 15. Incident Management Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation	▪ Monitor CCTV cameras, system detectors, and radio broadcasts for incidents.	▪ Existing
	▪ Verify incidents using CCTV cameras and radio communications with ODOT crews.	▪ Existing
	▪ Patrol state highways for incidents.	▪ Existing/Planned
	▪ Dispatch ODOT incident responders, HazMat responders, or maintenance crews to an incident site when needed.	▪ Existing/Planned
	▪ Dispatch towing/salvage vehicles to incident sites.	▪ Existing
	▪ Provide all on-scene motorist assistance for minor incidents that do not require the presence of emergency management agencies.	▪ Existing
	▪ Provide on-scene support to emergency management agencies for major incidents.	▪ Existing
	▪ Implement alternate routes for major incidents.	▪ Existing
	▪ Post incident messages on permanent and portable dynamic message signs.	▪ Existing
	▪ Turn ramp meters on or off to manage traffic near an incident or on an alternate route.	▪ Existing
	▪ Implement coordinated traffic signal timing plans for incident operations.	▪ Future
Oregon Department of Transportation	▪ Share information and device control (as applicable) with other TOCs.	▪ Existing/Planned
	▪ Share information with 911 centers using OIS message broker.	▪ Existing/Planned
	▪ Provide support to local traffic management agencies when resources are available.	▪ Existing
	▪ Provide incident information to travelers using the TripCheck system.	▪ Existing
Local Traffic Management Agencies	▪ Post incident messages on permanent and portable dynamic message signs.	▪ Existing/Future
	▪ Implement coordinated traffic signal timing plans for incident operations on alternate routes.	▪ Existing/Future
	▪ Share information and device control (as applicable) with other TOCs.	▪ Existing/Planned
	▪ Share information with 911 centers using OIS message broker.	▪ Future
	▪ Provide incident information to travelers using TLE and TTIP.	▪ Programmed
External State Departments of Transportation	▪ Post incident messages on permanent and portable dynamic message signs.	▪ Existing/Future
	▪ Share information and device control (as applicable) with ODOT TOCs.	▪ Existing/Planned
	▪ Share information with 911 centers using OIS message broker.	▪ Future

Stakeholder	Roles and Responsibilities	Status
	▪ Provide incident information to travelers using TLE and TTIP.	▪ Programmed
Local Public Safety Dispatch Agencies	▪ Dispatch law enforcement, fire and life safety, and emergency medical services when required. ▪ Contact ODOT TOC when ODOT incident responders are required. ▪ Share information with TOCs and other 911 centers using OIS message broker.	▪ Existing ▪ Existing ▪ Programmed
Oregon State Police	▪ Exchange calls for service with ODOT TOCs. ▪ Provide ODOT TOCs with access to TOW rotation application data. ▪ Provide OSP vehicle(s) and personnel at an incident site on state highways when dispatched. ▪ Share information with TOCs and 911 centers using OIS message broker.	▪ Existing ▪ Existing ▪ Existing ▪ Existing/Planned
Local Law Enforcement	▪ Provide local law enforcement vehicle(s) and personnel at an incident site per roadway jurisdiction when dispatched.	▪ Existing
Local Fire and Life Safety	▪ Provide fire and life safety vehicle(s) and personnel at an incident site when dispatched. ▪ Lead the incident command at the incident site per the *Emergency Operations Plan*.	▪ Existing ▪ Existing
Emergency Medical Service Providers	▪ Provide ambulance(s) and medical personnel at an incident site when dispatched.	▪ Existing
Commercial Salvage and Towing Operators	▪ Provide salvage or towing vehicle(s) and personnel at an incident site when dispatched by ODOT.	▪ Existing
Mayday Service Providers	▪ Take service calls from customers. ▪ Share information about Oregon incidents with ODOT.	▪ Existing ▪ Existing/Planned

Emergency Management Operational Concept

The emergency management service area includes the mitigation, preparedness, response, and recovery actions associated with major emergencies larger in scale than incidents, which are defined in the Incident Management Operational Concept section. Emergencies include any manmade (e.g. riot, terrorist attack) or natural event (e.g. forest fire, earthquake, volcano) that threatens or causes the loss of life, injury to person or property, or financial loss at a local, regionwide, or statewide level. The operational concept for emergency management includes the additional ITS components used for emergency management beyond those already described in the Incident Management Operational Concept. See the ODOT Emergency Operations Plan31 and the State of Oregon Emergency Management Plan32 for detailed documentation of emergency management in Oregon. This section includes a summary of the emergency management vision, current applications, current issues, future applications, and stakeholder roles and responsibilities. The emergency management operational concept is illustrated with the incident management operational concept in Figure 15.

Emergency Management Vision

The vision for the emergency management service area is to safely and efficiently manage the Oregon transportation infrastructure during major emergencies through a coordinated effort to promote the safe travel/evacuation of the public, safe travel of emergency responders and life saving supplies, and economic recovery after disaster. This vision is supported by the following goals:

- Improve and enhance the safety and security of emergency responders, the traveling public, and the environment.
- Develop and strengthen partnerships on state, regional, and local levels.
- Integrate systems and communications between statewide partners to improve information sharing.
- Deliver key information to the decision makers at emergency operations centers.
- Inform travelers of emergency information and transportation system impacts in a timely manner.

Emergency Management Applications Today

The following emergency management applications impact the Oregon transportation network today:

- **Emergency Operations Centers (EOCs):** A number of emergency operations centers (EOCs) have been established throughout the state of Oregon and are activated when needed during a major emergency situation. The Oregon Emergency Coordination Center (ECC) is the single point of contact for an integrated state response to a major emergency or disaster. The ECC is a dual-function facility in that it is the day-to-day office of the Oregon Office of Emergency Management (OEM) and becomes the ECC in a state of emergency. When activated, the ECC is considered an operational extension of the Governor's Office. Table 16 includes a list of key EOCs that traffic management agencies coordinate with during major emergencies.

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[31] *Oregon Department of Transportation Emergency Operations Plan*. Revision 6. Oregon Department of Transportation, Office of Maintenance, Emergency Preparedness Committee, March 2010.

[32] *State of Oregon Emergency Management Plan, Vol. II: Emergency Operations*. Oregon Office of Emergency Management, September 2010.

Table 16. Key Emergency Operations Centers for Traffic Management Agencies

Local Traffic Management Agencies		ODOT*	
Scope of Emergency	**Center Activation**	**Scope of Emergency**	**Center Activation**
Statewide	ECC	Statewide	ECC/Agency Operations Center (AOC)
Countywide	County EOC	Regionwide	Region EOC
Citywide	City EOC	Districtwide	District EOC

* ODOT operates a number of EOCs/command centers. The EOCs listed in this table include the main points of contact for TOCs when emergencies affect the state highway system.

- **Oregon Emergency Response System (OERS):** OEM operates OERS, which is the single contact point for help from any state emergency response agency 24 hours a day. OERS notifies ODOT when the ECC is activated and when an ODOT representative is needed. ODOT notifies OERS when other agencies require ODOT assistance with emergency response.
- **Emergency Management Software:** The Office of Emergency Management (OEM) uses OpsCenter as their primary emergency management software tool and requires that counties and other agencies use OpsCenter for interaction with the OEM. ODOT uses WebEOC as its primary emergency management tool and also uses OpsCenter for interaction with the OEM.
- **Emergency Alert System (EAS):** The EAS is a national system that allows the President to address the public in the event of a national emergency using broadcast stations, cable systems, and satellite systems. The EAS is also used on a statewide level for emergencies in Oregon.
- **Emergency Warning/Alert Systems:** Numerous warning systems are used throughout Oregon to provide widespread notification of emergency situations. Information from these systems is disseminated to the public through various means including OERS, EAS, and the applications described in the Traveler Information Operational Concept section (e.g. TripCheck, TTIP). The following is a sampling of emergency warning systems used in Oregon:
  - Amber Alerts: These alerts are used to provide timely emergency information to the public regarding child abductions. TOC operators post amber alerts on dynamic message signs based on an agency's message hierarchy system and ODOT posts the alerts to the TripCheck system.
  - National Weather Service Alerts: The National Weather Service issues watch and warning information for severe weather and floods in Oregon. These are a key feature on the TripCheck website.
  - Earthquake Warning System: The National Earthquake Information Center provides notification about earthquakes within or near Oregon.
  - Tsunami Warning System: The U.S. West Coast and Alaska Tsunami Warning Center issues tsunami warnings through the Oregon Tsunami Warning Network.
  - Debris Flow Early Warning System: The Oregon Department of Forestry issues advisories and warnings regarding debris flow.
  - Chemical Stockpile Emergency Preparedness Program (CSEPP) Alerts: County emergency management officials (Morrow and Umatilla Counties) will issue warnings in the event of a chemical accident involving nerve or mustard agents at the Umatilla Army Depot. ODOT and local agencies have specific plans for CSEPP emergencies

that include the use of ITS for disseminating evacuation information and contingency plans for TOC back-up.

Emergency Management Issues

The main emergency management issues include the following:

- System integration between TOCs and EOCs (primary and back-up) is currently limited. System interfaces do not exist between TOC and EOC systems. This presents obstacles to providing a timely coordinated response during major emergencies particularly since the key decision makers are typically stationed in an EOC and do not have immediate access to TOC information. Most TOCs and EOCs are located in separate buildings often separated by great distances although there are some local agency TOCs that are located in the same building as local agency EOCs.
- Major emergencies occur infrequently and emergency plans are often large and comprehensive. More frequent operator training is needed to ensure efficient emergency response procedures are in place.

Emergency Management Applications Tomorrow

Emergency management applications of tomorrow will address system integration issues and include the following:

- **EOC and TOC Integration:** Integration of EOC and TOC systems will streamline coordination activities and allow easier sharing of information between centers as well as shared traffic device control (e.g. CCTV cameras, dynamic message signs, traffic signal operations). This will provide key decision makers with comprehensive information and the flexibility to operate ITS applications from a number of various centers while also providing systems back-up functionality. The TOCS, OIS Message Broker, and WebEOC Software currently under development will play a key role in systems integration. Their functionality may be expanded to achieve integration or a separate interface may be developed to allow interaction.
- **TOCS Software:** ODOT plans to develop a module in TOCS to communicate with WebEOC. TOCS will also include a simulation mode that will make it easier to conduct drills on the emergency response plans and procedures.

Stakeholder Roles and Responsibilities

Table 17 includes the high-level roles and responsibilities for managing the Oregon transportation network as part of the emergency management service area.

Table 17. Emergency Management Roles and Responsibilities

Stakeholder	Roles and Responsibilities*	Status
Oregon Office of Emergency Management	▪ Activate the Oregon Emergency Communication Center (ECC) per the State of Oregon Emergency Management Plan. ▪ Act as an extension of the Governor's Office during statewide emergencies. Lead emergency management/operations coordination. ▪ Share information with EOCs throughout Oregon.	▪ Existing ▪ Existing ▪ Existing
Oregon Department of Transportation	▪ Activate ODOT EOCs per the ODOT EOP. These may include the Agency Operations Center, Region EOCs, District EOCs, Resource Management Center, Bridge Section Command Center, and Information Systems Command Center. ▪ Report to ECC during statewide emergencies and support their coordination efforts. ▪ Share information and device control (as applicable) between TOCs and ECC/EOCs.	▪ Existing ▪ Existing ▪ Existing/Planned
Federal Land Agencies	▪ Request assistance from ODOT or local traffic management agencies through the EOC/OERS.	▪ Existing
Local Offices of Emergency Management	▪ Activate local EOCs per local protocols. ▪ Report to ECC during statewide emergencies and support their coordination efforts.	▪ Existing ▪ Existing
Local Traffic Management Agencies	▪ Report to local EOCs during emergencies and support their coordination efforts. ▪ Share information and device control (as applicable) between TOCs and EOCs.	▪ Existing ▪ Existing/Planned
External State Offices of Emergency Management	▪ Activate the State EOC per state protocols. ▪ Lead emergency management/operations coordination statewide. ▪ Share information with Oregon ECC.	▪ Existing ▪ Existing ▪ Existing
External State Departments of Transportation	▪ Activate DOT EOCs per state protocols. ▪ Share information and device control (as applicable) with ODOT TOCs and ODOT EOCs.	▪ Existing ▪ Existing/Planned
Public Transportation Service Providers	▪ Provide transportation services for evacuations and reentry during emergencies.	▪ Existing/Planned
Commercial Transportation Service Providers	▪ Provide transportation services for evacuations and reentry during emergencies.	▪ Existing/Planned

* Detailed emergency management roles and responsibilities are included in the *ODOT Emergency Operations Plan and the State of Oregon Emergency Management Plan*. The roles and responsibilities listed in this table provide a high-level overview of agency interaction for traffic management and operations during a major emergency.

Archived Data Management Operational Concept

The archived data management service area includes the tasks associated with archiving, sharing, and analyzing historic ITS data. This section provides a summary of the vision, current applications, current issues, future applications, and stakeholder roles and responsibilities. generally depicts the operational concept for archived data management.

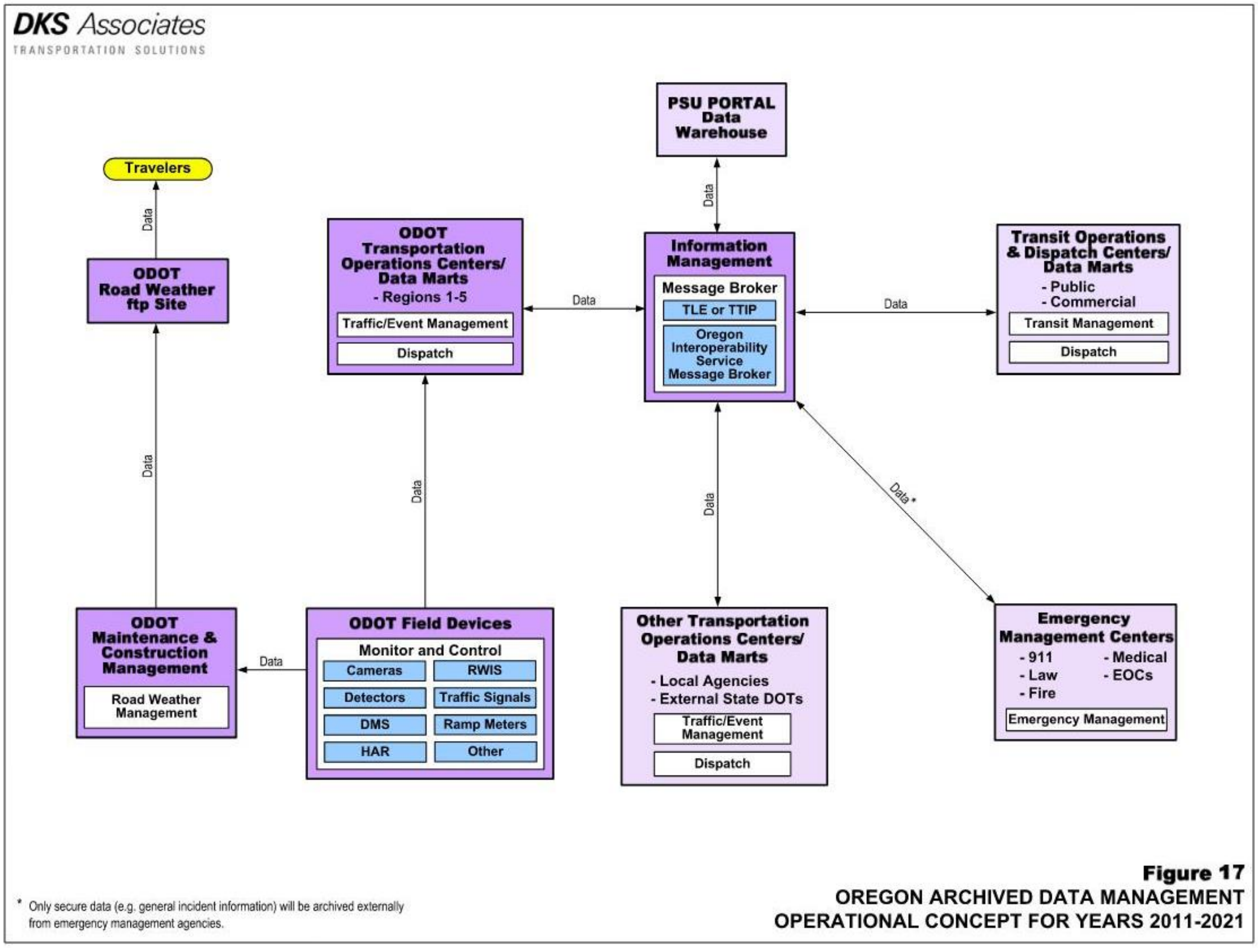

Figure 17. Oregon Archived Data Management Operational Concept for Years 2011 - 2021

Archived Data Management Vision

The vision of archived data management is to create systems that will improve the understanding of the relationship between operational, maintenance, and other ITS activities and roadway system performance by providing tools for collecting, archiving, and sharing information/data throughout ODOT and partner agencies. Goals that support this vision include the following:

- Archive agency-specific ITS data in-house.
- Archive non-secure ITS data in the centralized PORTAL data warehouse and make it available to the public.
- Develop analytical planning tools for performance measure assessment, alternative operational actions, asset management, and financial decision making. Automate these tools as much as possible.

- Develop predictive algorithm applications using archived data to generate travel forecasts based on real-time data.

Archived Data Management Applications Today

Applications of the archived data management service area today include the following:

- **Agency Data Marts:** A number of agencies operate and maintain their own data marts (e.g. Port of Portland, TriMet, ODOT). These data marts typically archive data for agency-specific systems and most are not currently shared with any other agencies. Some data marts such as TriMet's Enterprise Data Mart use real-time data for daily operations in addition to archiving data.
- **ODOT Data Warehouse:** ODOT uses the Highway Management Information System (HMIS) to warehouse all of its data marts and has developed a strategic plan for the execution and delivery of data warehousing and business intelligence (DW/BI) capabilities. The HMIS Data Warehouse delivers a number of capabilities that collect data from operational systems, organize the data to support analysis activities, and provide tools for business analysis, reporting, modeling, and geospatial analysis. Capabilities delivered by the HMIS Data Warehouse:
  - Access to relevant, timely, and accurate financial, project, and performance data
  - Faster generation/turnaround of standard reports
  - Data extracted from different operational ODOT systems is integrated into a format that supports analytics
  - Validated and cleaned data to prevent bad data from entering the data warehouse environment or user analytics or reports.
  - Data transformed into a single, standard format that is based on a single, accepted definition
  - Query processing is high performance, so that users are not unnecessarily waiting for results

Standard reports that are authoritative, reliable, and present the data in a manner that is easy to understand and easy to access.

- **PORTAL Data Archive:** Portland State University (PSU) houses the regional ITS data warehouse for the Portland and southwest Washington metropolitan areas. The PORTAL system currently archives freeway system detector loop data from ODOT and WSDOT, traffic signal system detector data from the Portland regional TransSuite central signal system, TriMet transit data, and local weather data from NOAA. PSU is already working closely with other regional stakeholders in the Portland and southwest Washington metropolitan areas to expand the system to include more data. The PORTAL data is accessible via the Internet and is designed for use by researchers, transportation planners, and transportation operators. PSU is currently developing tools to measure system performance.

PORTAL Home Page

Archived Data Management Issues

Issues currently associated with archived data management include the following:

- There are vast amounts of data being collected every second of the day by existing ITS devices and systems. Archiving and sorting this data in a usable format is a challenge.
- Limited efforts have been made to develop and quantify performance measures of ITS implementations. This is in part due to the lack of readily available data for analysis.
- Techniques and methods for utilizing archived data to produce traffic forecasts have yet to be fully developed.
- Future federal funding programs will likely require the use of performance measures to demonstrate the benefits of ITS projects.
- Data quality improvements are needed to achieve the vision for archived data management.

Archived Data Management Applications Tomorrow

The archived data management applications of tomorrow will support a comprehensive data warehousing and management strategy that will interface with existing and/or future ITS data sources. These include the following:

- **ODOT Data Warehouse Expansion:** Expand the ODOT data warehouse to include asset management and budget data.
- **Archived Data Expansion:** The future archived data expansion will address the archived data needs of the entire state either through the expansion of the PORTAL system or through other solutions. Each agency will archive the data to the detail they deem necessary for sharing with other regional and statewide agencies.
- **Data Exchange Interfaces:** Automatic data exchanges between ODOT and local traffic and transit management agencies will be key to the archived data management strategy. The interfaces to push, pull, and translate data between agencies will need to be developed so that it is usable in activities such as transportation planning, design,

research, and analysis. This includes developing data exchange interfaces with new equipment as it is deployed in the field.

- **Transportation System Network Monitoring:** ITS data are critical to understanding how well ODOT operates the highway network. The ability to generate and report performance measures using ITS data will be an integral piece of the future archived data management systems in Oregon.
- **Performance Measurement:** The archived data systems will be expanded to monitor performance measures on the entire transportation system. In particular, performance measures will be expanded to arterial roadways. Reporting tools will be automated to provide performance measures, manage assets, and guide financial decisions. These tools will be used by local, regional, and statewide planners and decision makers.
- **Predictive Algorithm Applications:** The ITS data captured and stored will be used to refine predictive algorithms that can be used to provide better feedback regarding the condition and operations of the transportation system performance. Improving travel time and traveler delay estimates are examples of applications with a predictive algorithm element.

Stakeholder Roles and Responsibilities

Table 18 includes the detailed key stakeholder roles and responsibilities for the archived data management service area.

Table 18. Archived Data Management Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Portland State University	▪ Maintain existing PORTAL data warehouse for Portland and southwest Washington metropolitan areas.	▪ Existing
	▪ Collect and archive data from additional archived data sources at other agencies. ▪ Develop system upgrades to PORTAL to include statewide archived data. ▪ Develop interface between PORTAL and regional/statewide data warehouses in neighboring states. ▪ Develop analytical tools to guide planning decisions. ▪ Monitor transportation system network performance. ▪ Develop predictive algorithm applications to forecast travel conditions.	▪ Existing/Planned ▪ Planned ▪ Existing/Planned ▪ Planned ▪ Existing/Planned ▪ Future
Oregon Department of Transportation	▪ Design/construct/maintain/operate field equipment that supports automated data collection. ▪ Maintain ODOT data marts (TOCS, ATMS, etc.). ▪ Define performance measurement standards to monitor transportation system network performance. ▪ Design/maintain infrastructure that supports data transfer to ODOT data marts and the PORTAL data warehouse.	▪ Existing/Planned ▪ Existing ▪ Existing/Planned ▪ Existing/Planned
Local Traffic Management Agencies	▪ Design/construct/maintain/operate field equipment that supports automated data collection. ▪ Maintain agency-owned data mart(s). ▪ Design/maintain infrastructure that supports data transfer to agency-owned data mart(s) and the PORTAL data warehouse.	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned
Public Transportation Service Providers	▪ Design/construct/maintain/operate field equipment and in-vehicle systems that support automated data collection. ▪ Maintain agency-owned data mart(s). ▪ Design/maintain infrastructure that supports data transfer to agency-owned data mart(s) and the PORTAL data warehouse.	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned

Public Transportation Operational Concept

The public transportation operational concept describes the statewide concept for advanced public transportation systems in Oregon.[33] It describes advanced public transportation systems that can be applied to improve the customer experience including systems that deliver real-time transit traveler information, and improve the speed and reliability of transit vehicles. The operational concept is intended to be a high level planning document because the number of stakeholders, and variety of systems applied in Oregon varies significantly. As stakeholders consider the public transportation operational concept, understand that each public transportation provider will likely not deploy all the systems presented in this concept. But, the advanced systems presented here could be used by any public transportation agency as they grow and take advantage of new technologies. Therefore, this operational concept should be a resource for public transportation stakeholders considering new technologies to improve service and the customer experience.

The public transportation operational concept primarily describes the roles and responsibilities of the stakeholders as they relate to advanced public transportation systems such as automated vehicle location (AVL), transit signal priority (TSP), transit security systems and traveler information. To achieve this end, the operational concept presents the statewide public transportation vision, applications in use today, issues impacting implementation, applications envisioned tomorrow (in the future), and concludes with a description of stakeholder roles and responsibilities relative to the “future” applications. Figure 18 depicts the Oregon public transportation operational concept.

Stakeholders should understand that the systems presented in the Oregon Architecture and Operational Concept categories have some overlap. For example, the public transportation operational concept describes transit traveler information applications, but these systems are also described briefly in the traveler information operational concept. Therefore, when considering traveler information projects, the reader should also refer to the other operational concepts for a complete description of the envisioned services.

Public Transportation Vision

The role of public transportation is to support and enable the attainment of the vision for transportation as outlined in ODOT’s *Oregon Transportation Plan*. That vision is:

> “By 2030, Oregon’s transportation system supports people, places and the economy. We travel easily, safely and securely, and so do goods, services and information. Efficient vehicles powered by renewable fuels move all transportation modes. Community design supports walking, bicycling, travel by car and transit wherever appropriate. Our air and water are dramatically cleaner, and community sensitive and sustainable transportation solutions characterize everything we do.”

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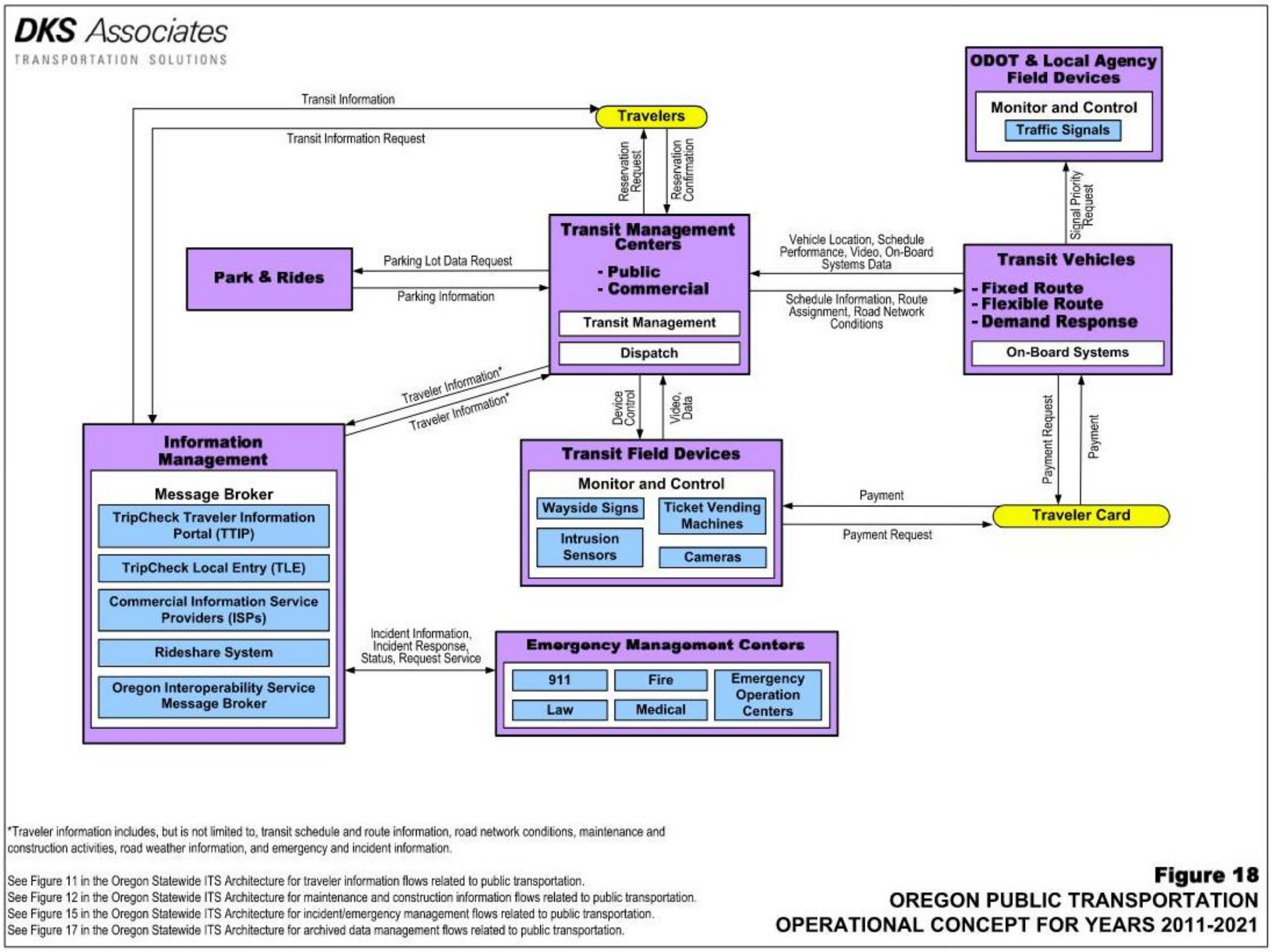
[33] See Attachment A for example public transportation ITS projects as defined by the Federal Transit Administration (FTA). The attachment summarizes the following document: *National ITS Architecture Consistency Policy for Transit Projects*, which can be accessed via http://www.fta.dot.gov/documents/dc2003.pdf



*Traveler information includes, but is not limited to, transit schedule and route information, road network conditions, maintenance and construction activities, road weather information, and emergency and incident information.

See Figure 11 in the Oregon Statewide ITS Architecture for traveler information flows related to public transportation.
See Figure 12 in the Oregon Statewide ITS Architecture for maintenance and construction information flows related to public transportation.
See Figure 15 in the Oregon Statewide ITS Architecture for incident/emergency management flows related to public transportation.
See Figure 17 in the Oregon Statewide ITS Architecture for archived data management flows related to public transportation.

Figure 18. Public Transportation Operational Concept for Years 2011 – 2021

Public Transportation Applications Today

Currently the focus of public transportation applications in Oregon is in the areas of transit management, transit traveler information, transit security, and archived data management. The degree of transit technology in use varies from one community to another.

Transit Management

Transit management includes technology services that improve transit operations by automating systems, deploying monitoring capabilities, and improving communications. Transportation providers around the state use the following transit management applications to varying degrees:

- **Fixed-Route Transit Dispatch Systems:** Some transit agencies use automated systems to dispatch, monitor, and schedule fixed-route services. These systems are often used in conjunction with transit vehicle tracking.
- **Transit Vehicle Tracking:** Some transit agencies equip transit vehicles with devices to track the vehicle location. Tracking vehicles supports dispatch activities and the dissemination of real-time transit traveler information.
- **On-Board Vehicle Systems:** Some agencies equip transit vehicles with systems such as automated passenger counters, voice communication systems, and other technologies to support route planning and improving the customer experience.

- **Transit Signal Priority:** Some transit agencies use transit signal priority along corridors with fixed-route transit services. Fixed-route transit vehicles are equipped with a device that communicates with traffic signals and extends the green time of a signal phase to reduce transit travel times and improve reliability.
- **Fleet Maintenance Systems:** Some transit agencies use automated vehicle data to track when regularly scheduled maintenance is due for vehicles.

Transit Traveler Information

Traveler information allows transit users to make pre-trip and en-route plans using phone, web-based, or kiosk systems. Transit agencies around the state use the following traveler information technology services:

- **Pre-Trip Traveler Information:** Numerous transit agencies provide a web or phone based system that provides travelers with route and fare information.
- **En-Route Traveler Information:** Several transit agencies provide a web or phone based system that allows travelers to access real-time schedule information while en-route. En-route transit information is also provided remotely on electronic signs at transit stops or at information kiosks. Real-time information often includes, but is not limited to, next arrival times, trip planning, and detour information.
- **Automated Stop Announcements:** Transit agencies use automated announcements on fixed-route transit vehicles to inform passengers of the next stop. These announcements are typically verbal but some transit vehicles also include visual announcements on electronic signs.

More information about connections between traveler information systems and public transportation is included in the Traveler Information Operational Concept of this Oregon Statewide ITS Architecture and Operational Concept Plan document.

Transit Security

Transit security applications allow transit agencies to monitor transit areas and improve the safety of transit users. Transit agencies around the state use the following transit security technology services:

- **Closed-Circuit Television (CCTV) Cameras:** Several transit agencies use CCTV cameras to monitor security on-board vehicles, at transit stops or centers, at park and ride facilities, or at agency facilities (e.g. transit garage or lot).
- **Intrusion Sensors:** Intrusion sensors are used on a limited basis to monitor key transit infrastructure (e.g. tunnel used for light rail).
- **Emergency Telephones:** Some transit agencies provide telephones at transit stops, centers, or park and rides that travelers may use for emergency assistance.

Archived Data Management

Several transit agencies use automated methods to transfer data from transit vehicles or systems to a database for archiving. The archived data is used for performance measurement, transit planning, and federal transit reports. For example, TriMet uses an automated method to transfer their transit data to the Portland regional transportation data warehouse (PORTAL). More information about connections between data management systems and public transportation is included in the Archived Data Management Operational Concept of this Oregon Statewide ITS Architecture and Operational Concept Plan document.

Public Transportation Issues

The prominent public transportation issues affecting implementation in Oregon today include the following:

- Few public transportation service providers are currently able to provide comprehensive real-time transit traveler information, which is in high demand from the traveling public.
- Lack of a statewide transit plan limits our ability to move to common system standards.
- Smaller public transportation service providers must dedicate most or all of their resources to providing services instead of advancing transit technology.
- Federal reporting does not take full advantage of automated transit systems.
- The lack of common system standards presents difficulties sharing data between public transportation service providers as well as providing statewide transit traveler information.
- Coordination between public transportation service providers and emergency management agencies is done through phone calls and does not use automated data exchange between systems.

Public Transportation Applications Tomorrow

Public transportation applications of tomorrow will automate many transit management activities, provide comprehensive statewide transit traveler information, enhance transit security, archive transit data, and support emergency management.

Transit Management

Tomorrow's applications will continue to automate as many transit management processes as possible to streamline operations:

- **Fixed-Route Transit Dispatch Systems:** Transit agencies will use an automated system to dispatch, monitor, and schedule fixed-route services. This will be used most effectively in conjunction with transit vehicle tracking.
- **Demand Response Reservation and Dispatch Systems:** Transit agencies will use a system to take reservations and to dispatch, monitor, and schedule demand response transit services.
- **Integrated Fixed-Route and Demand Response Reservation and Dispatch Systems:** Integration of these systems supports automated coordination at transfer points, optimizes service options, and maximizes the efficiency of reservations and route assignments for special transit user needs.
- **Transit Vehicle Tracking:** Transit vehicles will be equipped with vehicle tracking devices to improve transit system management and transit traveler information.
- **On-board Systems:** More transit vehicles will be equipped with automated passenger counters, voice communication systems, or other technologies to support operations.
- **Transit Signal Priority:** Transit signal priority will be used on corridors with fixed-route transportation services to improve on-time transit performance and reliability.
- **Road Network Conditions:** Transit dispatchers will have access to a variety of road network conditions from traffic management agencies and will adjust transit service as needed. Road condition information includes real-time and predictive travel speeds on key regional corridors, traffic incident impacts, and planned maintenance and construction activities.
- **Fleet Maintenance Systems:** Transit fleets will use automated monitoring services that indicate when routine maintenance is due for activities such as engine maintenance (e.g. oil changes, battery replacement), lift service, or other on-board system maintenance.

- **Regional Fare Cards:** Fare cards will be used to allow travelers to pay for transit services throughout a region using a single card.

Transit Traveler Information

Tomorrow's applications will include comprehensive static and real-time transit traveler information that is seamless throughout Oregon:

- **Statewide Multimodal Trip Planning Tool:** Travelers will plan multimodal trips (transit, car, bicycle, walking) throughout the state of Oregon from a single website or smart phone application. To support statewide trip planning transportation service providers will use standardized data (general transit feed specification, GTFS) and share it with TripCheck and commercial information service providers.
- **En-Route Traveler Information:** En-route and real-time transit information (such as next arrivals, connections, delays, detours, and parking availability at transit parking lots) will be readily available to transit users.
- **Personalized Traveler Information:** Technology applications that provide information specific to individual users based on unique requests, past transit patterns and traveler preferences will be used to provide personalized information.
- **Rideshare System:** A single website and telephone rideshare system will be used statewide to match interested travelers. This system will integrate rideshare programs currently used in different areas of Oregon. ODOT currently plans to implement a system called RideShare Online (managed by King County, Washington) in 2011.

Transit Security

Transit security systems (CCTV cameras, intrusion sensors, and emergency telephones) will continue to be installed on transit vehicles and at transit stops, centers, park and rides, and other transit facilities.

Archived Data Management

Data will automatically be archived in agency data marts and regional or statewide data warehouses. This data will be used for system network monitoring, performance measure evaluation, asset management, financial decision making, and federal transit reporting. More information is included in the Archived Data Management Operational Concept of this Oregon Statewide ITS Architecture and Operational Concept Plan document.

Emergency Management

Transportation service providers will coordinate with emergency management agencies to support emergency evacuation and reentry using transit vehicles. Emergency management systems will be integrated with transit dispatch systems so emergency management agencies are able to track transit vehicle locations in real time. More information is included in the Emergency Management Operational Concept of this Oregon Statewide ITS Architecture and Operational Concept Plan document.

Stakeholder Roles and Responsibilities

Table 19 includes the stakeholder roles and responsibilities for the public transportation service area.

Table 19. Public Transportation Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Public Transportation Service Providers	▪ Design/construct/integrate/maintain/operate transit systems and transit field devices. ▪ Dispatch fixed-route vehicles. ▪ Manage reservations and dispatch demand response and flexible route vehicles. ▪ Coordinate service with other public transportation service providers at system transfer points. ▪ Lead the installation of transit signal priority with ODOT and local traffic management agencies. Provide transit signal priority equipment on transit vehicles. ▪ Manage the logistics of determining eligibility for special categories of transit riders (low income, elderly, students, etc.)	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned
Commercial Transportation Service Providers	▪ Manage reservations and dispatch vehicles.	▪ Existing/Planned
Oregon Department of Transportation	▪ Encourage and support using the ITS Architecture for project planning and implementation. ▪ Act as a liaison for the rest of ODOT. ▪ Fund advanced public transportation system improvements. ▪ Provide coordination and oversight in the procurement and implementation of new ITS projects. ▪ Design/construct/maintain/operate transit signal priority equipment associated with traffic signals. ▪ Operate traffic signals with transit signal priority and monitor performance.	▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned ▪ Existing/Planned
Local Traffic Management Agencies	▪ Design/construct/maintain/operate transit signal priority equipment associated with traffic signals. ▪ Operate traffic signals with transit signal priority and monitor performance.	▪ Existing/Planned ▪ Existing/Planned
Travelers	▪ Provide feedback on transit system, passenger amenities, and transit information to transit management. ▪ Pay for public transportation services using a traveler fare card.	▪ Existing/Planned ▪ Planned
Event Promoters	▪ Coordinate with transportation service providers in advance of special events for transportation services.	▪ Existing/Planned

Road User Charging Operational Concept

This Road User Charging Operational Concept is the starting document to harmonize and rationalize the approach to road user charging operations in the State of Oregon. While the legal definitions and rationale to employ tolling to raise revenue as a financing measure for specific facilities (e.g. bridges), congestion pricing to manage travel demand on congested facilities in urban centers, existing weight-distance tax collection system for trucks and distance based taxes for electric and hybrid vehicles accessing the road network, may all be different, the revenue collection mechanisms should provide drivers, both in and out of state, a common interface and harmonized approach to payment of all charges due. Likewise, the incorporation of the above road user charging mechanisms should integrate seamlessly with the existing and future ITS architecture to provide synergy of traffic data, information, and systems management.

This road user charging operational concept includes the vision, current applications, current issues, future applications, link to the National ITS Architecture, and stakeholder roles and responsibilities. This introduction section provides definitions for road user charging terminology, definitions for generic stakeholders, and a graphical depiction of the operational concept.

Road user charge and the variety of charges that fall under this category are defined as:

- Charge: This is a generic term for the price required for using the transportation network and it encompasses taxes, tolls, fees, and fares.
- Tax: All taxes require legislative approval and the money generated from transportation taxes goes into the Highway Trust Fund, which is allocated using a specific rule set. Existing taxes in Oregon include the fuel tax and weight-distance tax for trucks. A proposed tax is under legislative review for electric and hybrid vehicles since these unique vehicles do not currently pay their fair share of road user charges imposed on internal combustion engine vehicles through the fuel tax. A similar distance tax may be considered in the future for all vehicles to supplement or replace the fuel tax.
- Toll: This is the amount of money charged to use or access a particular facility (e.g. bridge, tunnel, roadway) and the revenue is used to pay back the debt for building that facility and to fund ongoing operations, maintenance, and management of the facility.
- Fee: Although similar to a toll, fees may be set by the legislature or local jurisdictions such that revenue may be used as the agency sees fit, subject to enabling statute or ordinance. Example fees include vehicle registration, parking, and cordon (e.g. traveling through a downtown area).
- Fare: A fare is payment for a service and is generally associated with public transportation or commercial transportation (e.g. shuttles, taxis).

Figure 19 shows the variety of potential road user charges that are in use or may be used in the future in Oregon. Collection of the road user charges that apply at a statewide level (e.g. existing weight-distance tax and potential future distance tax) are key factors in this operational concept because they drive the system requirements for road user charge collection. All other charges are additive but should be collected using the same system as the statewide charges.

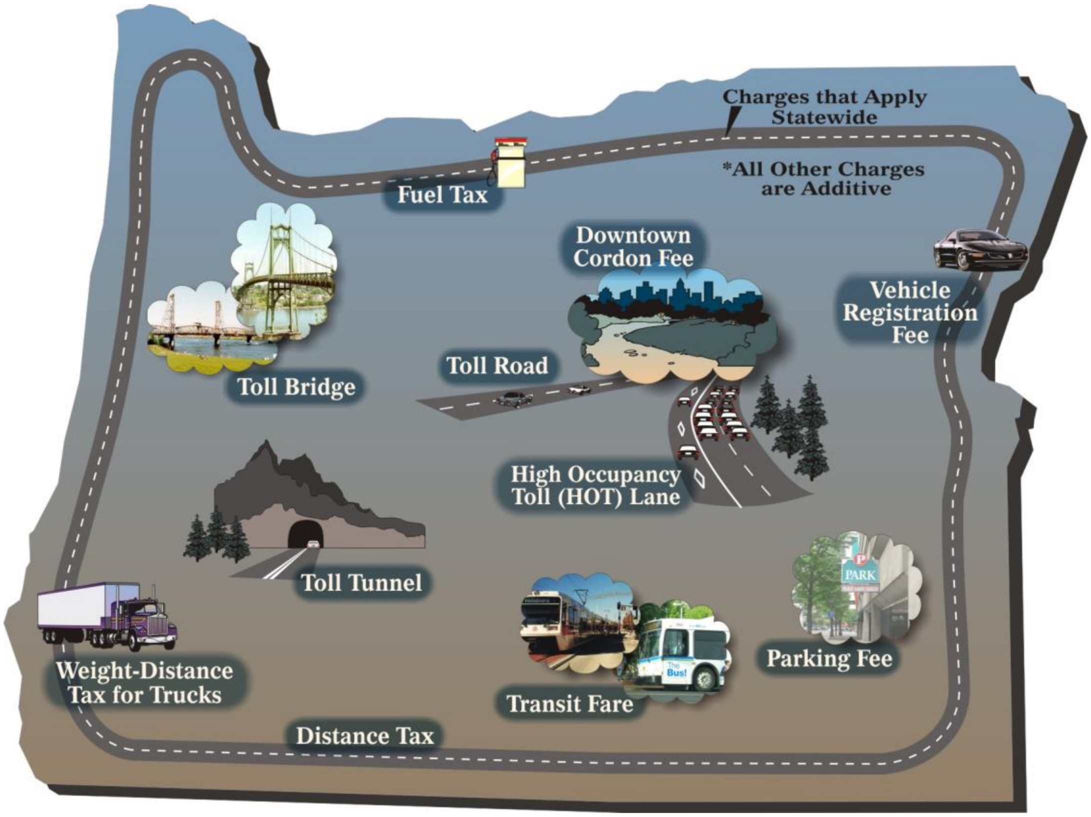


Figure 19. Existing and Potential Oregon Road User Charges

Unlike other well-defined stakeholders (e.g. ODOT) in this plan, there are a few generic stakeholders specific to road user charging used throughout this operational concept that require some definition:

- Road Owners are the entities responsible for the roads/bridges/tunnels/facilities and their maintenance to standards in the State of Oregon. For most state and public roads the Road Owner is ODOT, counties, and incorporated cities, but this title can also include other local jurisdictions and private operators.
- Charging Entities are the primary administrators or road user charges and they manage user accounts, collect transaction data (e.g. road usage and payment), handle exempt accounts, help set pricing, operate roadside equipment and work with enforcement to address non-compliant travelers. A Charging Entity may also be the Road Owner, a local jurisdiction, a private operator, or a contractor hired by a Road Owner.
- Trusted Third Party Service Providers (TTSPs) act as a middleman between Charging Entities and travelers who wish to use an intermediary. TTSPs are typically entities such as mobile phone service or credit card providers or financial institutions that travelers already entrust with financial and private information. The TTSP may also provide other value added services of interest to travelers, which enhances the rationale of why travelers choose to use an intermediary.
- Certification Agents are independent parties that test, manage configuration control, and certify that TTSPs' electronic road user charging collection systems meet the protocol standards set by the Charging Entities.
- Enforcement Agents are the responsibility of the Road Owner and Charging Entities for monitoring and ensuring compliance of travelers to pay their fair share of road usage

and may use all legal means available to ensure a high level of compliance. The party responsible for enforcement will vary for each different type of road charge.

Figure 20 depicts the Oregon road user charging operational concept using mostly generic stakeholders because many political and institutional decisions about road user charging roles and responsibilities have yet to be made. The figure includes details about how specific stakeholders such as ODOT will likely fit into the operational concept.

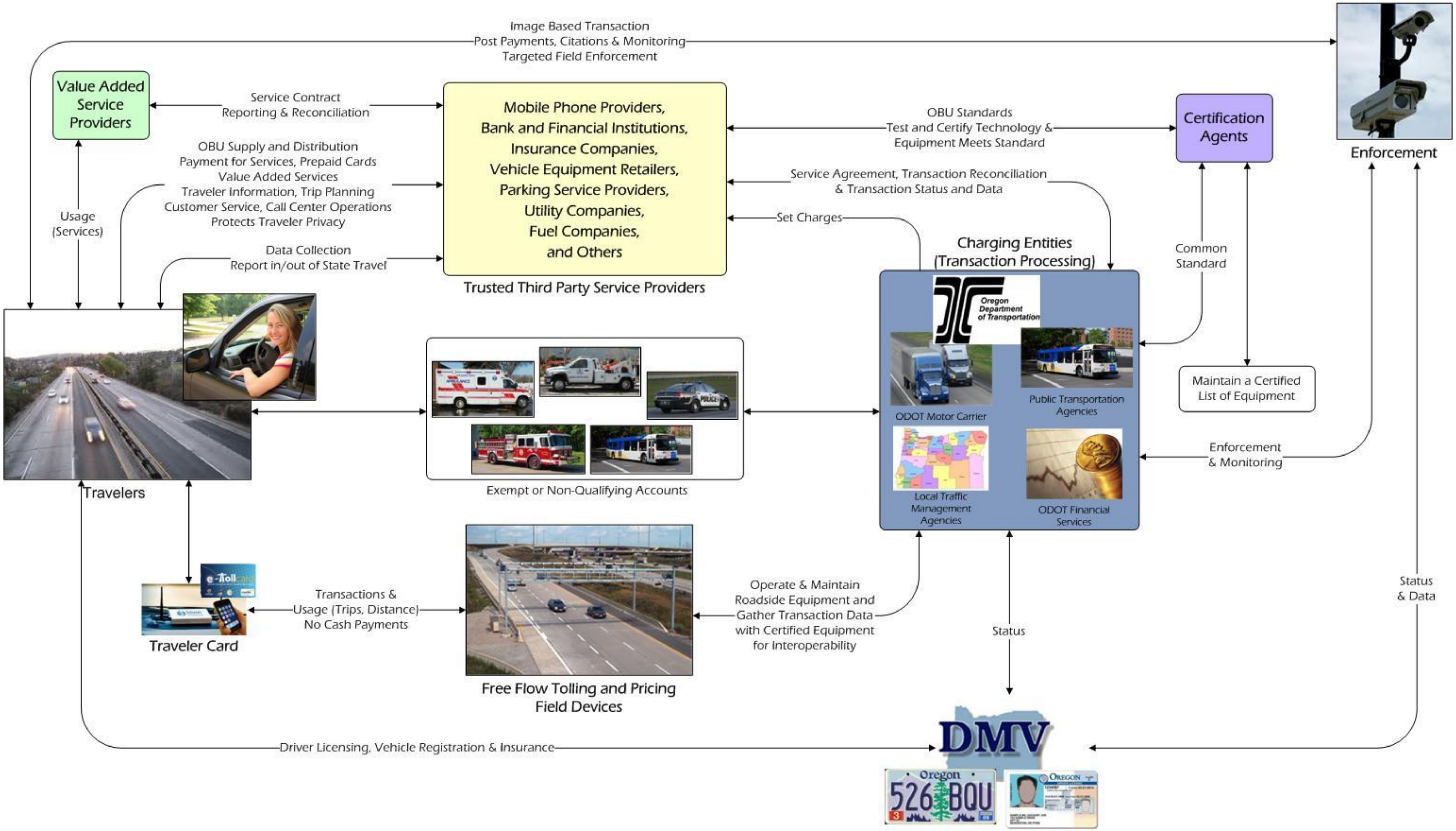


Figure 20. Oregon Road User Charging Operational Concept for Years 2011 – 2021

Road User Charging Vision

The Oregon road user charging vision is to operate a reliable, easy to use, relatively low cost, enforceable, publicly acceptable "open" system that collects road user charges using interoperable components that conform to common standards[34]. The aim is to provide a common user interface to seamlessly pay all road user charges in Oregon. This vision is supported by the following goals:

- **Establish public and private partnerships** to develop a system that allows travelers to interface with the Trusted Third Party Service Provider of their choice but pay multiple Charging Entities (e.g. ODOT, local agencies, public transportation providers, parking providers).
- **Protect privacy** by not mandating GPS-based charging systems but allow Trusted Third Party Service Providers to use GPS-based charging technology for interested travelers.
- **Support collection of a variety of transportation charges** including, but not limited to, a statewide mileage based user tax, congestion pricing, facility tolls, and local options.
- **Provide free-flow electronic charging systems** that allow charging without vehicles being required to stop or slow down.
- **For mileage based systems, only charge Oregon residents for in-state travel** unless travelers report mileage undifferentiated by geographic location and until systems in Oregon and neighboring states have matured enough to consider addressing non-Oregon residents.
- **Verify exempt travelers** such as public service providers (e.g. emergency vehicles).
- **Operate an efficient government-owned back office system** that allows the flexibility for modules for various subsystems (e.g. Motor Carrier Transportation Division) and interfaces to back office systems operated by Trusted Third Party Service Providers. The system will provide one place for travelers to access all their road user charges.
- **Use industry standards** for the system components that need to be interoperable for an efficient and cost-effective system.
- **Offer incentives** to encourage the private sector to act as the Trusted Third Party Service Providers and provide data collection, payment services, and other value added services.
- **Provide travelers with choices** regarding road usage reporting, selection of technology and Trusted Third Party Service Providers, and methods for invoicing and payment.
- **Enforce payment violations** to ensure compliance of travelers.

Road User Charging Applications Today

Oregon uses limited road user charging applications today for automobiles but does have a well-operated weight-distance tax system for heavy trucks. This section describes applications in use in the United States, other countries, Oregon (weight-distance truck tax, Hood River-White Salmon Bridge), and Washington (Tacoma Narrows Bridge). But first, it is important to understand the difference between closed and open system road user charging architecture models.

Overview of Closed and Open System Architecture Models

The primary difference between closed and open system architecture models is the degree of user choice. In a closed system model a traveler's only option is to interface directly with the Charging Entity whereas in an open system model a traveler may choose to interface with the Charging Entity or any number of Trusted Third Party Service Providers who provide account management services along with possible value added services.

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[34] Vision statement is based on Road User Fee Task Force policy objectives.

The definition of a Closed System is an internally integrated system controlled by a single entity with essential components that cannot be substituted by other external components, which could perform the same functions. This is essentially a monopolistic model because the Charging Entity selects a charging system (e.g. software, tag and reader system) from one manufacturer., who typically has intellectual property rights to the equipment, both hardware and software, and "Locks-in" the Charging Entity and the users[35]. Travelers who wish to use the Charging Entity's facilities must comply with the Charging Entity's rates and rules (e.g. requirement to purchase a specific tag reader). This system does not provide travelers with any options for how they interface with the system[36]. Figure 21 illustrates a closed system road user charging model.

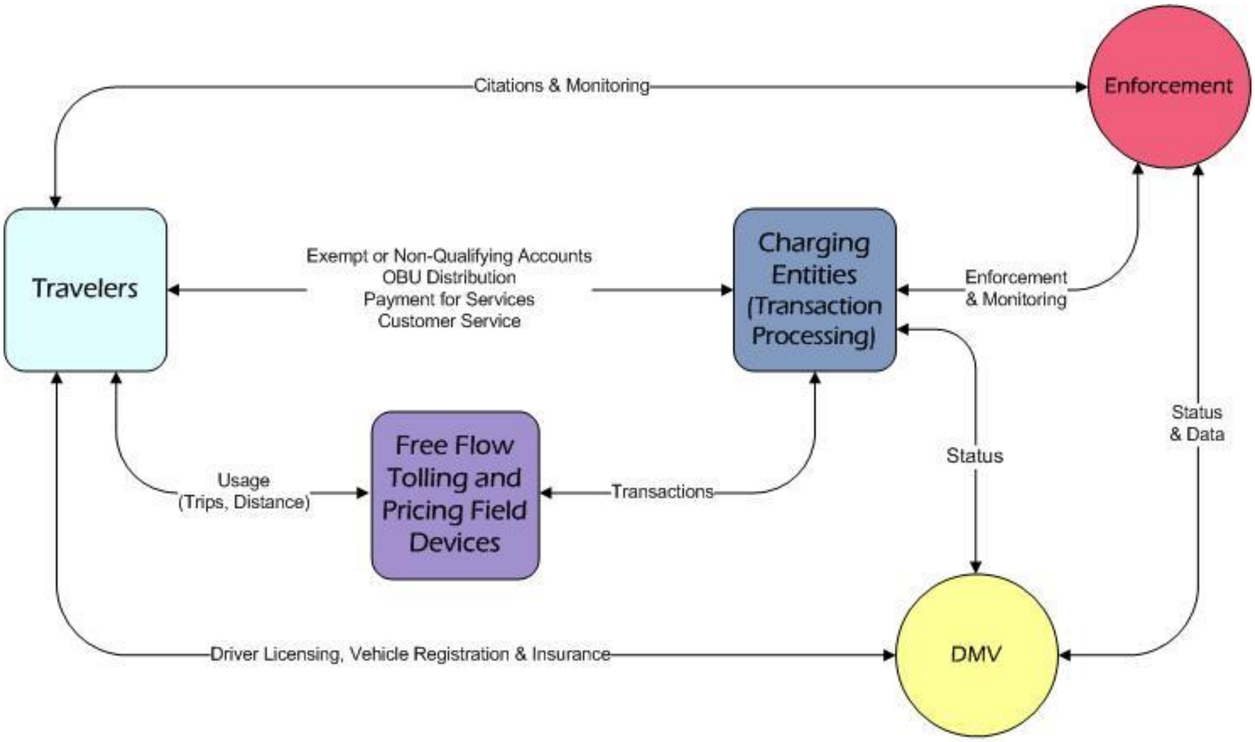

Figure 21. Closed System Road User Charging Model

An open system architecture model, on the other hand, is run by one or multiple Charging Entities using an integrated system based on common standards whereby interoperable components performing the same function can be readily substituted. Under this model travelers have accounts and submit payment for transportation services to the TTSP of their choice. The TTSP forwards the applicable payment to the Charging Entity. To appeal to travelers, TTSPs typically offer other services or structure the account and payment service plans that appeal to travelers. For example, a mobile phone company may act as, or partner with, a TTSP to allow travelers to use their mobile phones to interface with a charging system and to pay for toll charges as well as their parking payments and local transit usage in

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[35] RITA, ITS Joint Program Office Report, *ITS technology adoption and observed market trends from ITS deployment tracking*, Final Report, October 8, 2010, p.13, p.28 & p.34.

[36] IBID

conjunction with the daily trips they make. Their billing is posted on their monthly mobile phone bill, which they pay to the mobile telephone company that shares the revenue with the TTSP. Figure 20 shows an open system model system for Oregon. This system is described in more detail under the *Road User Charging Applications Tomorrow* section.

Background on Road User Charging in the United States

Agencies throughout the United States use a small number of closed proprietary systems for road user charging as shown in Figure 22. The manufacturers of these systems compete intensively to procure exclusive contracts with road user charging authorities, which are then “locked-in” to use only that manufacturer’s equipment. The operational costs (road user charge collection, administration of accounts, and enforcement) of these “closed systems” is 37%[37] as a percentage of revenues of road user charging authorities in the USA. The proprietary hardware and software of these manufacturers is not interoperable with other manufacturers’ systems and the cost to change out individual components and the system is prohibitive.

As road user charging has become more of a mainstay for transportation financing, some agencies have been forced to use proprietary systems already in use by other agencies in the region. Interoperability exists to some extent on a regional basis, but as an exception rather than a rule. For example, Texas has selected a proprietary technology as their state standard. California created their “Title-21” tags and the standard is readable only by the tag supplier’s equipment. The Interagency Group procures all of its readers and tags from one manufacturer. In many cases, each government agency tasked to operate road user charging facilities procures their system separately and tends to procure what they consider the best “deal” for themselves without regard for other charging facilities in the region or state. Some regions, such as Central Texas, have recognized the efficiencies and cost savings of an open system model and are working towards introducing TTSPs to their existing systems; however, there is a limited number of TTSPs who risk their business model on a single, sole source of supply.

These practices have promoted “closed systems” rather than “open systems” and have limited both interoperability and the addition of value-added services. Historic system codependences also limit the market’s ability to change. Road user charging administration in the past collected cash for each driver’s trip. The accounts and the management were controlled and operated by the road user charging administration. As electronic road user charging collection entered the market, although these were new business functions more aligned by the commercial and financial world, the road user charging administration shouldered the responsibility. As a result, rather than evolving with the new technology and reinventing the industry along more efficient lines, road user charging industries in foreign countries, without any historic system codependences, evolved in “open system” models and corroborated with commercial partners and the financial markets to reduce their ratio of operating costs to revenue percentage less than 10 percent.

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[37] *NCHRP Project No. 19-08 (Costs of Alternative Revenue-Generation Systems), Interim Report #1*. Dec. 2009, p.57.

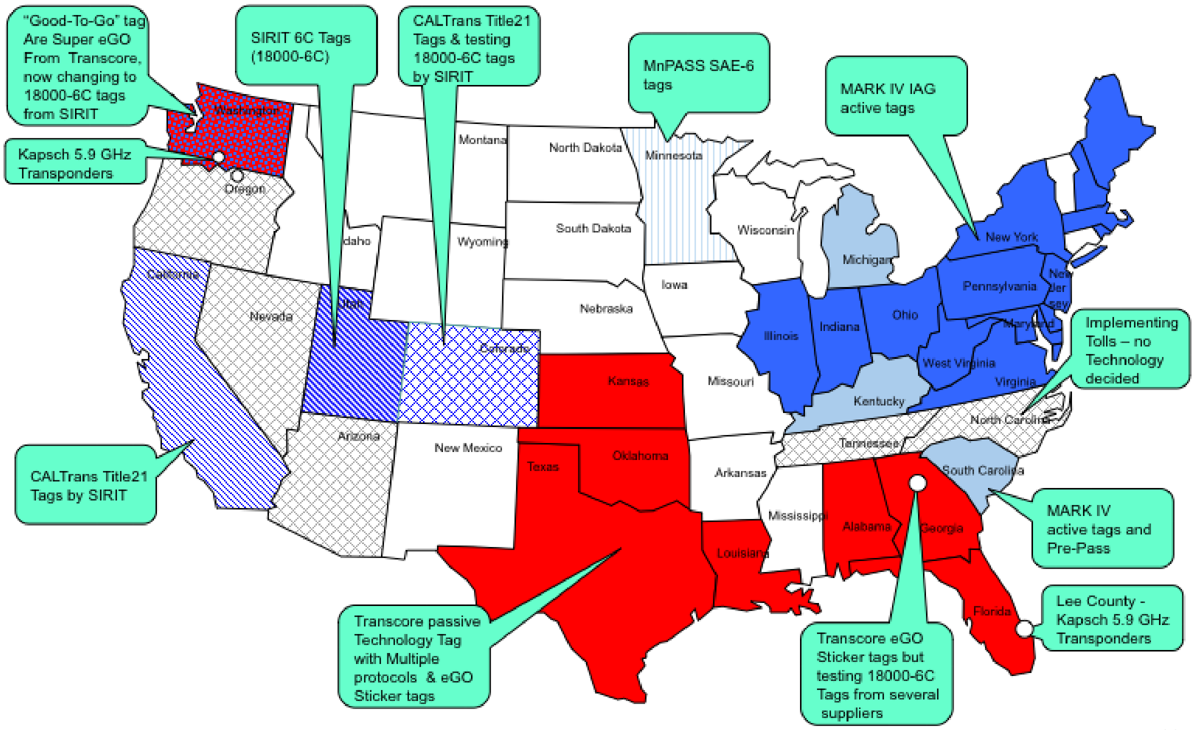

Figure 22. Proprietary Road User Charging Systems Used in the United States[38]

Background on Road User Charging in Other Countries

Newer road user charging systems in other countries are following open system models. A few highlights:

- The overhead for public agencies to operate open systems in Singapore, Portugal, and the United Kingdom averages 8 to 10 percent.
- Scandinavia successfully developed an interoperable electronic toll collection system in 2007. EasyGo, a TTSP, provides service for 40 Charging Entities, including several ferry operators, for customers in Norway, Sweden, and Denmark.
- New Zealand successfully replaced its 1977 closed Road User Charging system for diesel vehicle mass and distance charges to an open system in 2007.

Oregon Weight-Distance Tax for Heavy Trucks

The ODOT Motor Carrier Transportation Division (MCTD) operates a weight-distance tax system for vehicles that weigh more than 26,000 pounds. The current system relies on manual reporting. Most motor carriers report their weight-distance tax on a monthly basis. Motor carriers meeting certain conditions may report their tax on a quarterly or annual basis. MCTD is currently taking steps to implement an electronic reporting system and envisions the use of TTSPs in the future.

Hood River-White Salmon Interstate Bridge Tolling System

The Port of Hood River was the first to introduce electronic tolling to Oregon in 2007 and is still the only agency in the state to use electronic tolling. The Hood River-White Salmon Interstate Bridge originally was opened to traffic in 1924 by the Oregon-Washington Bridge Company. The west end of the bridge is in Hood River, Oregon, and the east end of the bridge is in White

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[38] *Ibid*. Figure 21.

Salmon, Washington. From 1924 until 2007, the Hood River-White Salmon Interstate Bridge operated manual tolling. In 2007, an electronic system was added to the existing manual tolling lanes to address the congestion and over demand at the toll collection booths. Electronic tolling is accepted in all four lanes and cash is also accepted in the inside two lanes by manual toll collection. This section describes the software, tag and reader system, accounting, auditing procedures, and customer system used for electronic tolling of the Hood River-White Salmon Interstate Bridge.

Software[39]

The software used for the Hood River-White Salmon Interstate Bridge tolling system provides users with web access to their accounts and must be compatible with both the hardware (gates, readers, lights) and accounting system. The tolling software used is Toltag, which is also used in Florida and on the New Jersey Turnpike. There are no licensing fees for the software, but ongoing customization is billed as needed by task.

Tag and Reader System[40]

The electronic toll collection system, BreezeBy, was launched in November of 2007 at the Hood River-White Salmon Interstate Bridge. Electronic, 915MHz TransCore eGo sticker tags and TransCore 2210 readers are used in the current tolling system. This system relies on Idris smart loops in the pavement that detect, track, and classify vehicles. The tags are radio based and are affixed to the windshield of the vehicle. There are a few problems with trucks because of the vertical windshields and metal visors. The system operates under slow speeds from 10-20 mph.

The Port of Hood River is also currently testing the 5.9GHz Kapsch readers and transponders in parallel with the current system. The 5.9GHz system is a nonproprietary standard and is expected to have better accuracy, localization, encryption, speed, and other performance aspects than the 915MHz devices. Early test results comparing the two technologies indicate these performance aspects to be true. The 5.9GHz transponder is also proving to offer better localization (determination of the position of the vehicle in the roadway).[41] The standard being used is the 802.11p protocol approved by IEEE.

Accounting, Auditing Procedures, and Customer System

The electronic tolling tasks are performed by the Port of Hood River. To set up an account, users can apply online, over the phone, by mail, or in person at the Port office. The Port office has six total staff; three people can set up electronic tolling accounts. A temporary employee worked part time to set up new accounts during the first month of operation. Approximately 4,100 accounts were opened for the BreezeBy electronic system and 10 to 20 new accounts are opened each week. The toll charged is based on the number of axles the vehicle has. Users who have a BreezeBy account receive a 20 percent discount on the cost of the bridge toll.

The Port provides the first three tags free to users. Tolling agencies in other states typically do not provide any free tags. Additional tags for the Hood River-White Salmon Interstate Bridge cost $15 for a standard tag and $27 for external tags for motorcycles or vehicles with dark tinted windows.

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[39] Garth Appanaitis', DKS Associates, phone interview with Linda Shames, Port of Hood River Finance Manager, Aug. 2010.

[40] *5.9 GHz ET Test at Hood River OR-White Salmon WA Toll Bridge over Columbia River.* TOLLROADSnews. Sept. 13, 2010 http://www.tollroadsnews.com/node/4897. Accessed Oct. 8, 2010.

[41] Telephone interview with Jerry Hautamaki, Hood River, February 2011. Note, no test results provided, but verbal confirmation received.

Tacoma Narrows Bridge Tolling System

The Tacoma Narrows Bridge, which is the first facility in Washington to use an electronic toll collection system, is located approximately eight miles west of Tacoma and approximately 40 miles south of Seattle and is operated by WSDOT. The new Tacoma Narrows Bridge (SR 16) is a parallel span to the south of the existing bridge. The new Narrows Bridge carries eastbound traffic, while the westbound traffic uses the 1950 Narrows Bridge. The new Narrows Bridge opened to traffic in July 2007. It had been nearly twenty years since the last facility had been tolled in Washington. This section describes the tag and reader system, accounting, auditing procedures, and customer system used for electronic tolling of the Tacoma Narrows Bridge.

Tag and Reader System

The Good To Go! system is the electronic tolling option used in the state of Washington that uses TransCore eGo sticker tags. The sticker tags are using 915 MHz technology with the 18000-6B (proprietary) standard for the Tacoma Narrows Bridge tolling and for the SR 167 HOT Lanes Pilot Project. Tolling on the SR 520 bridge will begin in spring 2011. WSDOT recently awarded a new contract to Sirit Inc. for supply of a newer generation 18000-6C sticker tag (which still uses 915 MHz technology) and are in the process of changing over to this standard.

On the Tacoma Narrows Bridge, there are two options for paying the toll. Drivers can stop and pay manually with cash or credit at the toll plaza or they can pay electronically without stopping. The WSDOT had originally planned to accomplish electronic tolling by having travelers use a prepaid Good To Go! Account, which requires a transponder on the vehicle’s windshield and can be prepaid online. The transponder is supposed to allow the driver to maintain highway speeds by remaining in the express lanes without stopping at the toll plaza. However, it turns out the Good To Go! transponders are not interoperable with the transceiver equipment on the Tacoma Narrows Bridge[42]. For now WSDOT plans to use image based tolling to keep traffic moving.

Accounting, Auditing Procedures, and Customer System[43]

There is no charge to sign up for a Good To Go! account and applications are accepted online, over the phone, or by mail. Now that image based tolling is being used, license plates captured on video will be checked to see if there is a corresponding Good to Go! account and charges will be applied automatically through the Good To Go! account. Travelers without Good to Go! accounts will receive a bill in the mail. Currently, violators without a Good To Go! transponder and that skip the toll booths are issued a $52 citation. Pay By Mail will give them up to 80 days to pay their toll bill before being issued a citation[44].

WSDOT has a toll operations contract with TransCore. TransCore operates and manages aspects of the Tacoma Narrows Bridge toll system including in-lane operations, violations processing, customer service, maintenance, accounting, and financial reconciliation for a fixed monthly fee. As part of WSDOT and TransCore’s toll collection and accounting system and operating agreements, WSDOT tracks and expects the following accuracy and performance measurement:

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[42] *WA’s new toll sticker unreadable on Tacoma Bridge*. Associated Press. March 17, 2011.

[43] *Statewide Tolling Operations Contracts for the Tacoma Narrows Bridge and SR 167 HOT Lanes Information Packet*. Washington State Department of Transportation. Feb. 2008.

[44] *Citizens Group Considers New Ways to Pay Narrows Bridge Tolls*. Washington State Department of Transportation. Sept. 27, 2010. http://www.wsdot.wa.gov/News/2010/09/_27AdvisoryCommitteeMeeting.htm. Accessed October 8, 2010.

- Handling 80 percent of inbound phones calls to the service center in 30 seconds
- Keeping the number of calls abandoned at three percent or less
- Fulfilling requests for new or replacement transponders within three days
- Processing 98 percent of license plate data from the video-toll system and sending to the Department of Licensing within two business days
- Correctly entering 99.9 percent of all license plate data on the first review

In addition, a high level of accuracy in electronic toll collection, vehicle classification, violation imagery, lane availability, and customer service center computer system availability is expected. These and other contractual measures are used by WSDOT to evaluate tolling operations with TransCore. WSDOT is responsible to pay direct reimbursable cost items including replacing and installing capital toll system equipment and significant system enhancements.

Road User Charging Issues

In Oregon and the United States, the following road user charging issues exist today:

- Throughout the United States the road user charging industry operates more like a set of local monopolies than a real market. The systems currently in operation are closed systems that use proprietary equipment.[45]
- Little has been done at the federal level to develop interoperable road user charging services. The National ITS Architecture includes limited standard protocols for road user charging and the electronic toll collection market package framework is set up for closed systems. The International Bridge, Tunnel and Turnpike Association (IBTTA) has held several conferences on interoperability but has not agreed on a way to change the status quo.[46]
- Historically the manufacturers and vendors in the market have not had strong enough incentives to overcome the challenges involved to establish interoperability. To the contrary, the manufacturers and vendors have actually spent lobby efforts to protect their current market.[47]
- Administrative and account management costs of closed system models are high. The estimated revenue to overhead ratio for handling transactions averages approximately 37 percent in the market[48].
- Development of an integrated back office system that captures all the functions associated with road user charging is challenging.
- The public is more hesitant to give their personal information (e.g. vehicle location, financial information) to a public agency than to private establishments.
- Non-Oregon residents are harder to charge and to enforce payment.
- Some travelers will refuse to participate in charging systems and try to avoid payment. Enforcement of violators is difficult because may travelers do not update their mailing address with the Department of Motor Vehicles and prosecution is expensive.

Road User Charging Applications Tomorrow

The Oregon road user charging applications of tomorrow will use an open system architecture model to collect mileage-based taxes to supplement or possibly in lieu of the current fuel tax, to improve the existing tax collection system for trucks, to collect tolls to raise revenue for specific facilities, and to use congestion pricing to manage travel demand on congested facilities. The

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[45] RITA, ITS Joint Program Office Report, *ITS technology adoption and observed market trends from ITS deployment tracking*, Final Report, October 8, 2010, p.28

[46] IBID, p.30

[47] IBID

[48] NCHRP Project No. 19-08, Interim Report #1, December 2009.

open system architecture model will also support the collection and processing of public transportation fares and parking charges for public agencies that wish to share the efficiencies of the system. This section describes the technology options for the roadside equipment and back office system, pricing and payment concepts, enforcement, principles for operating an effective open system, and a discussion of how road user charging systems fit with other statewide systems.

Technology Options for Road User Charging

Although the technology options may vary by the type of road user charge, the system components needed for road user charging fall into two main categories: roadside equipment and back office system. Travelers interact with both parts of the system as shown in Figure 23. This section provides a high level overview of roadside equipment and the back office system.

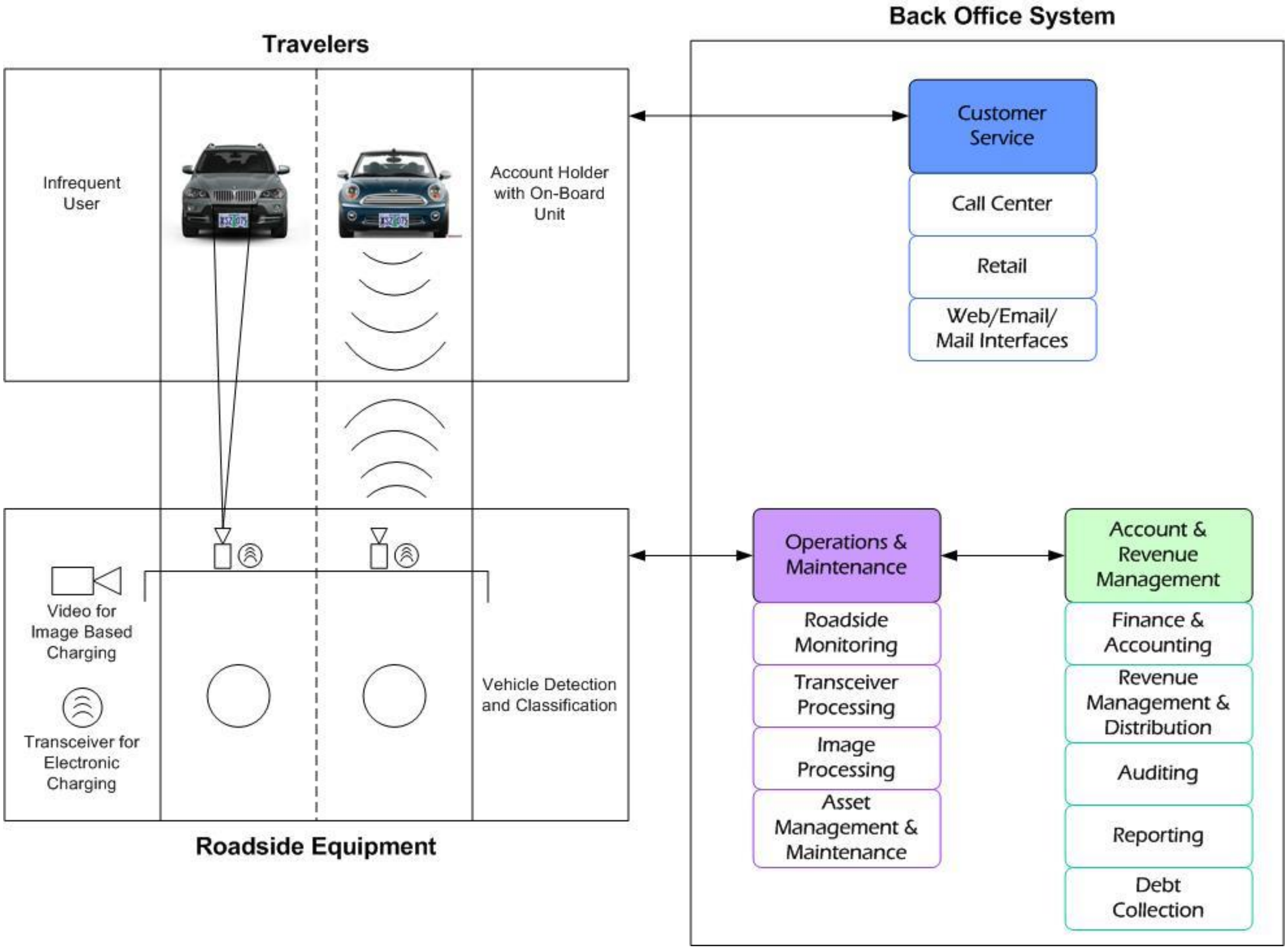

Figure 23. Road User Charging System Components

Roadside Equipment

For typical free flow road user charging applications, Oregon plans to deploy roadside equipment that supports three main functions:

1. Electronic road user charging
2. Image based road user charging
3. Vehicle detection and classification

Plazas with manual road user charge collection (e.g. cash or credit transactions in the field) are not desired to be used in order to keep traffic flowing and to minimize traveler and freight delays and overhead costs for road user charge collection. Cash payment will still be an option but collection methods other than physical plazas are being explored. This section describes each of the three roadside equipment functions for most charges, such as tolls and fees, as well as some variations for other road user charging applications.

Electronic road user charging will be accomplished by using a transceiver for each travel lane to communicate with vehicles that have an on-board unit (OBU). OBUs may be available in various forms such as tags (typically affixed to the windshield), an odometer subsystem, or mobile phones. Distribution and sale mechanisms for OBUs will vary by type of road user charge. Developing a standard protocol for communications between the transceiver and an OBU is one of the key pieces to a successful open system. The standard protocol must allow private industry the flexibility to develop innovative technologies for OBUs that attracts customers while also simplifying the requirements of the transceiver, which will be installed and maintained in the field by the Charging Entity.

Image based road user charging, also called video road user charging, will use a video camera for each travel lane to capture occasional users who choose not to obtain an OBU. The video camera will capture an image that will likely be used to identify a vehicle’s license plates or other distinguishing vehicular features. The owner of the vehicle captured on video will be sent a bill for the road user charge. Image based road user charging will be operated by a Charging Entity or a third party through a contract with a Trusted Third Party Service Provider.

Detection equipment will be used to count and classify vehicles to support accountability and payment reconciliation activities. In some cases this data will also be used to determine the appropriate price of the charge (e.g. rates based on number of axles or rates based on lane usage). This detection equipment is the same as that discussed in the Regional Traffic Control Operational Concept.

Additional hardware and software will be required in the field to run the equipment and to communicate with the back office system.

The exact configuration of the roadside equipment will vary by the road user charging application:

- Specific roadway or facility tolls or fees: Transceivers and video cameras will likely be installed over each travel lane on a gantry, which is an overhead structural support. Vehicle detection equipment may be installed overhead, in the pavement, or on the side of the roadway.
- Mileage based taxes: Oregon is still exploring options for the collection of mileage based taxes. One option currently under consideration is to install transceivers at key locations (e.g. Wi-Fi hot spots) to communicate with OBUs. In this case an OBU may be an

odometer subsystem. Vehicles without an OBU will likely be taxed through a separate non-roadside system where travelers report their road usage and pay accordingly.

- Public transportation fares: The fare box on-board the public transportation vehicle or at a station will likely act as a transceiver that communicates with an OBU carried on the traveler themselves.
- Parking fees: Transceivers will likely communicate with OBUs. Parking agencies may choose to continue the use of parking meters for occasional users, they may use video cameras, or they may develop an alternate system to capture vehicles without OBUs.

Back Office System

The back office system is the heart of the road user charging system that performs all of the functions necessary to account for travelers and their applicable charges and to facilitate funds transfers between participating parties. In a simplified view, the back office system handles the following major functions:

- Account creation and maintenance
- Road and customer data collection and processing
- Reconciliation and audit of road usage data and revenue collection and distribution
- Financial data processing and statistical reporting
- Administrative and operational supporting activities

ODOT envisions they will operate an integrated back office system[49] for the entire state that allows the flexibility for modules and interfaces with various subsystems. ODOT Motor Carrier Transportation Division already operates a back office system for the truck weight-distance tax system. This system will likely be a module within the statewide system. The ODOT system will be the default back office system should a traveler choose to process with the state rather than a TTSP. The back office will provide all the elements of a back office system (account management, customer service, invoicing, and accounts payable) in addition to a link to Treasury and to all certified TTSPs. Revenue will typically be accounted for in the Financial Services Branch regardless of who collects it. Debit accounts and pre-processing of transactions will be the only type of accounts managed by the ODOT back office system. The main back office system will need to be set up to be flexible and allow for future expansion.

Trusted Third Party Service Providers will operate their own back office systems but standard protocols must be established so that their systems will interface with the statewide system. Transactions accumulated by the Charging Entities will be aggregated by the ODOT state back office system and batched daily to the respective TTSPs who own the accounts of the Travelers. Reconciliation of the transactions and any discrepancies will be performed within 24 hours of receipt of a batch of daily transactions. Irregularities and abnormal transactions will be reported and reconciled in this time frame. It is envisioned that TTSPs will handle accounts for users on a post-pay basis. Risk of handling and receipt of payments will be the responsibility of the TTSP. Debt collection will also be the responsibility of the TTSP; however, the risk of recovery of non-payment or avoidance of payment for road charges once the TTSP properly notifies the Charging Entity of all attempts to recover overdue or past due charges becomes a shared responsibility with the Charging Entity. The Charging Entity will in turn alert Enforcement with the information provided by the TTSP and will assist the Charging Entity if travelers attempt to avoid paying their fair share of the charges due.

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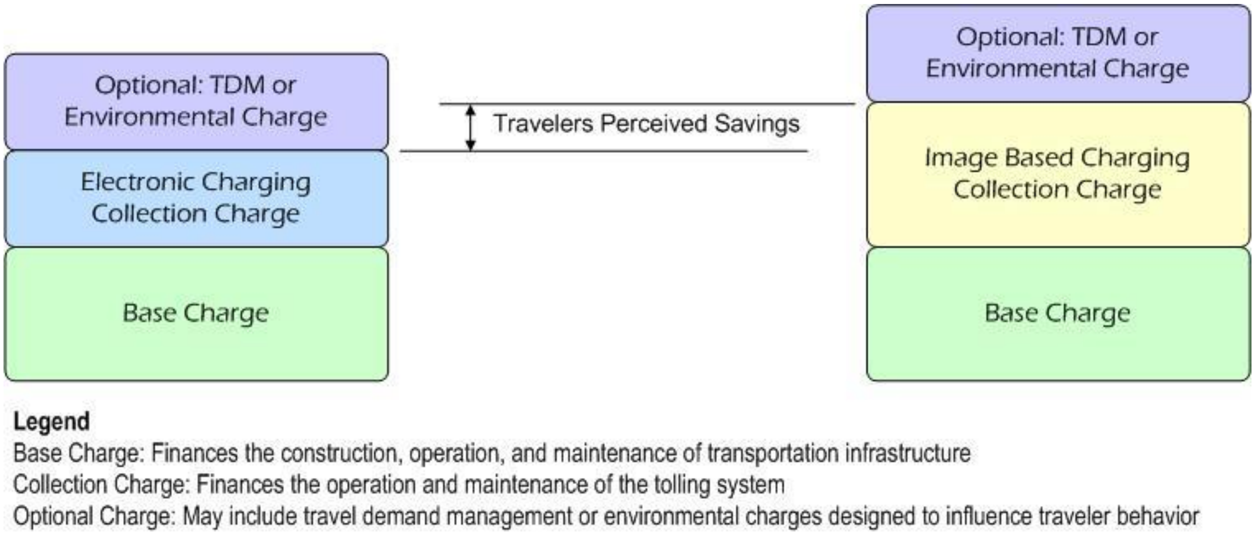
[49] The statewide back office system may be one system or an integrated collection of several systems.

Pricing and Payment Concepts

This section describes charge components, pricing methodology, payment options, and account types.

Figure 24 shows and defines the components of a roadway charge: base charge, collection charge, and optional charge. The collection charge is typically what influences a traveler's decision about whether or not to set up an account with a Trusted Third Party Service Provider. The equipment and overhead to operate electronic road user charging is typically less than image based road user charging; therefore, the collection charge for image based road user charging is higher. This also provides incentive for travelers who frequently use facilities with road user charges to work with a TTSP. Additionally, TTSPs who offer value added services (e.g. traveler information) at little or no cost also entice travelers to use their services because they perceive a better value in what they are purchasing.



Legend
Base Charge: Finances the construction, operation, and maintenance of transportation infrastructure
Collection Charge: Finances the operation and maintenance of the tolling system
Optional Charge: May include travel demand management or environmental charges designed to influence traveler behavior

Figure 24. Charge Components

Prices for road user charging may be set using a variety of methods:

- Distance: Everyone pays a fair share through a rate applied to the vehicle characteristics and the distance traveled within the Charging Entity's domain or along a specific link in the network.
- Event: A charge is set at a specific point or event along a facility (e.g. entrance to a bridge or tunnel) or is based on distance traveled since the last payment event.
- Zone: A charge is assessed if travelers choose to drive in a particular area or zone (e.g. downtown).
- Time Duration: A charge is based on how long a vehicle is present at a specific location or area (e.g. parking facility, state park, recreation area).
- Lane: A charge is established for use of part or the entire length of an express lane as a premium service during peak time and congestion periods (e.g. high occupancy toll lane).

Prices may vary by vehicle type, vehicle weight, (actual, rated gross vehicle weight, or weight bands), fuel efficiency, time of day, location of travel, or other incentive-based pricing schemes.

Although electronic payment is preferred, road user charging in Oregon will support the following methods of payment:

- Cash
- Check (bank or electronic)
- Money order
- Credit and debit cards
- Electronic funds transfer.

Approximately one-third of the population uses cash only and so it is vital to provide a cash payment option.

All travelers must set up an account with either a TTSP (preferably) or a Charging Entity. Each TTSP and Charging Entity must decide if they want to collect charges using pre-payment or post-payment:

- Pre-payment: Under this scenario travelers must keep a specified minimum amount of money in their account. As road user charges are incurred they are deducted from the money in the account. Pre-payment is a common practice in the road user charging industry.
- Post-payment: Under this scenario travelers are required to pay their account within a specified time period after road user charges are incurred. Post-payment is most familiar to travelers who are used to paying for services or utilities after they have consumed or used them.

Charging Entities will most likely require pre-payment to minimize risk of non-payment. TTSPs may make pre-payments to Charging Entities but allow travelers to provide post-payment. For road user charges administered by the state, payments are required to adhere to prescriptive legal requirements. Additionally, Charging Entities must allow for anonymous accounts to address some travelers' concerns over privacy. Anonymous accounts are recognized by a number rather than a name and do not provide any personal details to Charging Entities.

Enforcement

Enforcement is a key tool for fostering payment compliance and the type of enforcement used is dependent on the type of road user charge. Enforcement for road user taxes will be established by legal statute. For tolls, fees, and fares the enforcement system will be developed by the Charging Entity. Common enforcement methods used elsewhere include record comparison, targeted manual field enforcement of frequent violators, and mobile enforcement. Citations will be issued to travelers who do not pre-pay or post-pay for road user charges.

Principles for an Effective Open System Architecture Model

To operate an effective open system architecture model for road user charging, six principles should be followed:

1. **Principle 1: Travelers are required to self-declare their road usage.** Ideally travelers set up an account with a TTSP, who collects road usage and reports it to the Charging Entity. However, travelers may also report their road usage directly to the Charging Entity.
2. **Principle 2: Charging Entities set quality requirements for TTSPs.** TTSPs demonstrate their ability to report the road usage of their subscribers with no more than a certain error percentage in the amount paid per time period.

3. **Principle 3: TTSPs design their own solution for user choices.** This allows TTSPs to develop and use technology of their choice to measure and report road usage. This encourages innovation and creative solutions.
4. **Principle 4: Charging Entities monitor and control TTSPs.** Charging Entities measure accuracy and audit the reconciliation of revenues with each TTSP. TTSPs may be required to post surety bonds or guarantee their fiduciary standing.
5. **Principle 5: TTSPs monitor and control travelers.** TTSPs check compliance of travelers by remote OBU checks, statistical analysis, and process audits.
6. **Principle 6: Charging Entities monitor and control non-subscribing travelers.** Charging Entities use image based tolling to charge travelers the appropriate tolls. For mileage-based taxes alternate methods will be needed to monitor non-subscribing travelers.

How Road User Charging Systems Fit with Other Statewide Systems

The charging systems described in this operational concept introduce new interfaces with existing statewide systems as shown in Figure 25. Most importantly, traffic conditions data (e.g. vehicle count, classification, and speed) needs to conform to a common standard that interfaces with both charging systems and traffic management systems. Traffic conditions data collected by charging systems will be used by traffic managers in their day-to-day operations of the system and will also be fed to information service providers as traveler information and to archived data systems to support performance evaluation and transportation planning. Traffic conditions data that is channeled to charging systems will most likely be used for auditing and congestion pricing applications.

The open system architecture model lends itself to applications for public transportation fare and parking charge collection. Once the back office system and TTSPs have been established, public transportation and parking agencies could develop their own back office system modules to interface with TTSPs. This would allow travelers to pay for multiple services through one source. For instance, if a mobile phone service provider is a TTSP or partnered with a TTSP travelers could use their mobile phones to pay for roadway charges, public transportation fares, and parking charges as part of their normal monthly bill. A few agencies that may be interested in participating in the statewide open system during the next 10 years:

- Salem Cherriots: They plan to replace their fare box within the next few years with a system that allows the flexibility to perform electronic fare collection. They would like to run an electronic fare collection pilot study within the next year. Cherriots envisions the use of an open system and would like it to be interoperable with other public transportation agencies in Oregon.
- TriMet/C-TRAN: Within the next five years these two agencies plan to jointly procure an electronic fare system to replace their current fare boxes. They want to use an open system and are starting to explore available options.
- Rogue Valley Transit District: Their software includes an application for electronic fare collection but they do not own transceivers to support it. Currently they have other higher priority needs they must attend to.
- City of Portland: They conducted a business case study on a fully electronic parking system several years ago and will soon be conducting a pilot project that will likely use mobile phones for parking charge payments. As part of a future electronic system the City envisions the ability for travelers to reserve off-street parking and the ability to adjust parking prices based on congestion.

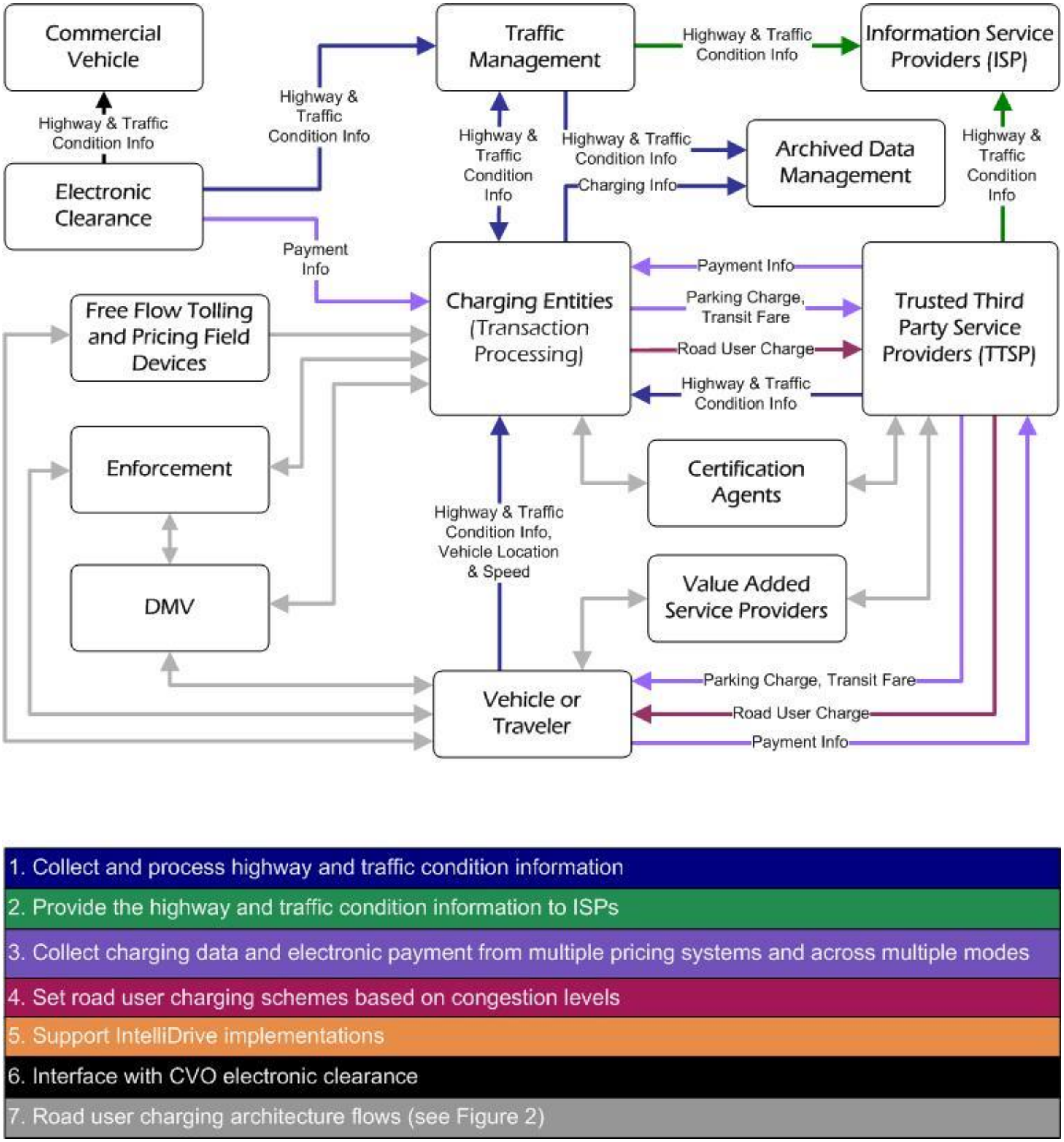


Figure 25. How Tolling Systems Fit with Other Statewide Systems

Road User Charging and the National ITS Architecture

The National ITS Architecture includes a user service for Electronic Payment Services that addresses electronic toll collection, transit fare payment, and parking payment. These areas are covered under three market packages: 1) Electronic Toll Collection (ATMS10), 2) Transit Fare Collection Management (APTS04), and 3) Parking Facility Management (ATMS16). The electronic toll collection market package is set up with a closed system architecture with a focus on interactions directly between the toll administration center and the toll collection field device.

It does not include TTSPs within the market package architecture. However, TTSP elements may be added to the statewide ITS architecture along with custom information flows to map the interfaces shown in this operational concept (Figure 19).

While the National ITS Architecture does include a few ITS standards associated with the electronic toll collection market package, much work still needs to be done to develop interoperable ITS standards. The data flow for “toll probe data” has been flagged as a candidate for future standardization and the following standards have been developed for use in some vehicle payment data flows:

- DSRC 5 GHz: Dedicated Short Range Communication at 5.9 GHz Standards Group
- DSRC 915 MHz: Dedicated Short Range Communication at 915 MHz Standards Group
- IEEE 1455-1999: Standard for Message Sets for Vehicle/Roadside Communications

The following automotive industry standards may be applicable for use by TTSPs:

- SAE J2266: Location Referencing Message Specification
- SAE J2735: Dedicated Short Range Communications Message Set Dictionary

ODOT and other road user charging stakeholders will need to work with national standards organizations to push for the development of ITS standards for an open road user charging system. This process needs to start now. The standards are constantly evolving to keep up with advancements in technology and most of the time they are backward compatible with earlier standards.

Stakeholder Roles and Responsibilities

Many political and institutional decisions still need to be made before defining specific road user charging roles and responsibilities; so Table 20 describes the typical roles and responsibilities for generic stakeholders and Table 21 identifies what potential stakeholders may fill these roles in Oregon. At the end of this section there is a discussion about the roles and responsibilities that ODOT anticipates taking on.

Table 20. Road User Charging Planned Roles and Responsibilities

Stakeholder	Roles and Responsibilities
Statewide Charging Standards Committee	▪ Identify data flows that require standardization for interoperability. ▪ Work with national standards organizations on the development of road user charging ITS standards. ▪ Establish interface and protocol standards for road user charging collection in Oregon.
Charging Entities	▪ Design/construct/maintain/operate roadside equipment (electronic toll transceivers, image based system, and vehicle count/classification system). ▪ Set prices, through the Oregon Transportation Commission as applicable, for all charging applications within the Charging Entity’s domain. These may be set by legislation (e.g. taxes). Pricing may also include base charges, travel demand charges, and environmental charges. ▪ Collect transaction data (road usage) from travelers either directly or indirectly through another Charging Entity.

Stakeholder	Roles and Responsibilities
Charging Entities (continued)	▪ Consolidate transactions by TTSP and reconcile with TTSP on payments. ▪ Audit and monitor TTSPs, customer surveys, and overall efficiency of system. ▪ Work with Enforcement Agent to enhance compliant behavior for travelers. Ensure non-compliance travelers who do not report road usage directly or travelers who attempt to avoid payments are prosecuted. ▪ Handle exempt accounts that legally are not required to pay charges. Once established by legislation, these may include transit vehicles, police vehicles, fire and life safety vehicles, state vehicles, military vehicles, etc. [One way to handle exempt accounts is to provide an OBU for vehicle tracking.] ▪ Handle accounts that do not qualify or choose not to do business with a TTSP.
Trusted Third Party Service Providers (TTSPs)	▪ Provide subscribing travelers with on-board units for their vehicles or provide alternate technology that is certified and compliant by the Certification Agent (e.g. smart phones with verified and compliant apps). ▪ Provide a service profile that offers travelers value over the Charging Entity service profile and operates at a lower operational fee (value for money). ▪ Optional: provide travelers with other value added services (e.g. traveler information) to entice them to use a particular TTSP over other TTSPs or the Charging Entity. ▪ Collect road usage data of subscribing travelers and collect payment from those travelers for charges and other value added services.
Certification Agents	▪ Test and certify that Charging Entities' and TTSPs' road user charging collection equipment meets the interface, common standards and protocol standards established by the Statewide Charging Standards Committee. ▪ Maintain and record configuration management of all road user charging collection equipment. ▪ Maintain and keep current a list of all certified road user charging collection equipment. ▪ Maintain and keep current on all changes to the common standards and keep the Charging Entities and TTSPs appraised of any changes and their impact.
Enforcement Agents	▪ Monitor travelers for charge compliance. ▪ Issue citations for non-compliant behavior. ▪ Report monitoring and enforcement activities to Charging Entity. ▪ Provide DMV with updated information about travelers and their vehicles when this information is collected through the enforcement process.
Value Added Service Providers	▪ Provide value added services either directly to travelers or as part of a package provided to travelers through TTSPs. ▪ Identify and provide unique value added services for the travelers' end-to-end experience.

Stakeholder	Roles and Responsibilities
Value Added Service Providers (continued)	▪ Be open to expanded markets and TTSP access to wider markets for services.
Oregon Driver and Motor Vehicle (DMV) Services Division	▪ Provide Enforcement Agent with access to statewide vehicle registration database.
Exempt (Non-Revenue) Account Holders	▪ Set up exempt accounts with Charging Entity. ▪ Optional: Maintain an operable road user charging on-board unit (OBU) in exempt vehicles.
Travelers (also called Road Users)	▪ Choose any TTSP or the Charging Entity to handle road user charge records and payments. ▪ Optional: Maintain an operable road user charging on-board unit (OBU) in the traveler’s vehicle or maintain alternate technology (e.g. mobile phone with GPS). ▪ Retain road usage mileage and facility usage records. ▪ Report road or facility usage to Charging Entity either directly or through the assistance of a TTSP. ▪ Promptly pay fair share of road or facility usage consumed.

Table 21. Potential Oregon Road User Charging Stakeholders

Generic Stakeholder	Potential Oregon Stakeholder
Charging Entities	▪ ODOT ▪ ODOT Financial Services ▪ ODOT Motor Carrier Transportation Division ▪ Public-Private Partnership Corporate Group or JV ▪ Local Traffic Management Agencies (for road use and/or parking) ▪ Public Transportation Service Providers ▪ External State Departments of Transportation ▪ External State Departments of Motor Vehicles ▪ External State Local Traffic Management Agencies
Trusted Third Party Service Providers (TTSPs)	▪ Bank or Financial Institutions ▪ Mobile Network Operators ▪ Credit Card Companies ▪ Utility Companies ▪ Navigation Unit Providers ▪ Insurance Companies ▪ Vehicle Equipment Retailers ▪ Fuel Credit Card Companies ▪ Traveler Information Service Providers ▪ Many other possibilities
Certification Agents	▪ Independent Electronics Laboratory ▪ University
Enforcement Agents	▪ Oregon State Police ▪ Local Law Enforcement ▪ Third Party law enforcement agency

Generic Stakeholder	Potential Oregon Stakeholder
Exempt (Non-Revenue) Account Holders	▪ Commercial HazMat Clean-Up Operators ▪ Commercial Salvage and Towing Operators ▪ Emergency Medical Service Providers ▪ External State Police Agencies ▪ Local Fire and Life Safety ▪ Local Law Enforcement ▪ Oregon State Police ▪ Public Transportation Service Providers

Anticipated ODOT Road User Charging Roles and Responsibilities

As the owner of the state highway system, ODOT will either take on all the roles and responsibilities of the Charging Entity for state facilities or will more likely take on some of the Charging Entity roles and responsibilities and contract the remaining ones to third parties. Road user charging roles and responsibilities that will likely be carried out by ODOT:

- ODOT:
    - Set pricing and implement road user charging systems based on direction from the Oregon Transportation Commission.
    - Design/construct/maintain/operate roadside equipment.
- ODOT Financial Services:
    - Collect charges from Charging Entities or TTSPs.
    - Perform charge collection accounting and auditing.
    - Conduct financial analysis and develop performance reports.
    - Perform enforcement.
- ODOT Motor Carrier Transportation Division (MCTD):
    - Introduce TTSPs and Certification Agents to MCTD’s existing weight-distance tax collection system for trucks to change it from a closed system to an open system.

Specific Oregon Transportation Commission (OTC) roles and responsibilities have been adopted into state legislation (e.g. ORS 184, ORS 383) regarding road charges. ODOT will work closely with OTC to carry forward any decisions made by OTC. For instance, OTC will likely approve all contracts for public-private partnerships that will establish the TTSPs.

Connected and Automated Vehicle Operational Concept

The connected and automated vehicle (CAV) operational concept describes the statewide approach for CAV technology and deployment in Oregon. Connected vehicles (CVs) are those able to send data to and/or receive data from their environments while in operation. Automated vehicles (AVs) are vehicles in which at least some portion of the vehicle's control operates without driver input. Together, connected and automated vehicle technologies present many opportunities to improve the safety, efficiency, convenience, and dependability of Oregon's transportation system. The systems involved are maturing rapidly, and their eventual use will require public agencies to provide the supporting institutional and physical infrastructure. Oregon can and should prepare for these developments.

This operational concept focuses on a 5-year time horizon and is intended to introduce current and future CAV applications, as well as to outline the immediate challenges that need to be overcome for these applications to be deployed in Oregon. AV technologies operate within the confines of a single vehicle, so most of their development can proceed independent of governmental action. However, many AV systems rely to a large extent on CV data that utilizes public infrastructure, which ODOT is principally responsible for managing and maintaining. Further, though outside the scope of this document, AVs operation will require new laws and regulations to be enacted by state and local government agencies, including ODOT.

Vision for Connected and Automated Vehicles

Oregon envisions using CAV technology to achieve improvements in safety, mobility, environmental benefits, and Agency operations efficiency. This vision is supported by the following goals:

- Significantly reduce crashes and fatalities on Oregon's roadways
- Improve safety for roadside workers and first responders
- Improve travel time reliability
- Reduce travel times and delay for transit
- Improve mobility options by providing travelers access to accurate travel time information and route options
- Improve air quality by reducing emissions
- Provide data to traffic maintenance and operations staff to:
    - Improve efficiency of Agency's operations
    - Accurately assess transportation system performance
    - Actively manage the transportation system in real-time
- Leverage data from the sensors to improve transportation planning processes

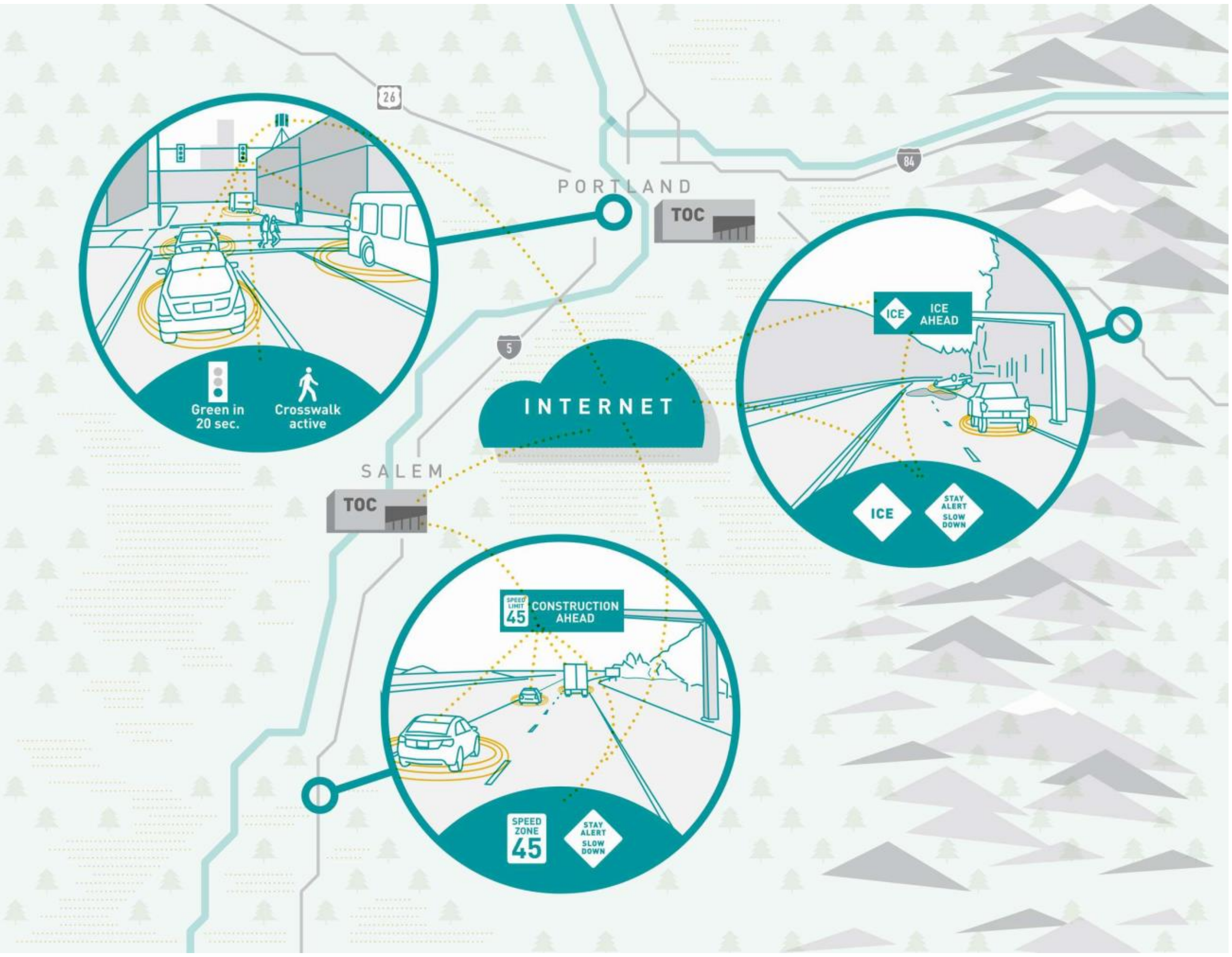


Figure 26. Oregon Connected and Automated Vehicle Concept.

Existing ODOT Systems That Support Connected and Automated Vehicles Application Deployment

ODOT has developed and currently deploys a number of advanced Intelligent Transportation Systems (ITS) that are well-positioned to take advantage of connected and automated vehicle technology. In many cases, CAV technology can provide immediate benefit to existing ODOT applications (in particular, queue warning, curve speed warning, and variable speed limits) by supplementing current information dissemination and data collection channels, thereby providing benefit to connected and non-connected vehicles alike. This shared benefit attribute is particularly valuable during the early stages of CAV adoption where fleet penetration rates are likely to be small. Examples of existing ODOT systems that are well-suited to CAV enhancements include the following:

1. *Advanced Traveler Information System (ATIS)*

   Advanced traveler information system is a general term for various technological means of aggregating and presenting transportation information to travelers. These can facilitate, among other things, trip planning and route guidance. Information presented can include traffic, transit, road weather and work zones. ATIS also serves as an integral part of many safety applications. Extensive data sources are required for ATIS. TripCheck is Oregon’s statewide traveler information service, providing information on road conditions, weather, construction, transit, parking, special events, etc. This information is compiled, processed, and disseminated through the TripCheck Traveler Information Portal (TTIP), where third-party services can access it. The data are currently distributed through the Internet (www.tripcheck.com), the 511 highway advisory telephone system, cable television presentations, Twitter, and a mobile app. Local agencies can update the system with information on planned or real-time events that affect specific road segments through the TripCheck Local Entry (TLE) tool. TTIP, in particular, is expected to be a key delivery mechanism for connected vehicle data from ODOT to the private sector.

2. *Travel Time Estimation*

   Travel time estimations combine data from roadway sensors and probe vehicles with information on congested locations to provide up-to-date travel time information to travelers. This service is already in place in on many Portland area freeways using variable message signs (VMS). With CAV, travel times could be delivered into the vehicle, in addition to using the roadside VMS. In some scenarios, and depending on a majority of vehicles being CAV, the roadside VMS may no longer be needed.

3. *Queue Warning*

   Queue warning systems alerts travelers approaching congested areas or a standing queue of vehicles, enabling informed routing and enhanced awareness of upstream conditions Systems can use roadway sensors, probe vehicles, and user-generated alerts to identify the location of the queue. Currently, this application is deployed on private smartphones using GPS-enabled applications such as Waze, as well as on Oregon Route 217 using roadway sensors and VMS. In a connected environment, the queue warning information could be delivered directly into the vehicle, and the real-time queue data collection, which ODOT currently collects with roadway sensors, could be supplemented with data from vehicles traveling the roadway.

4. *Variable Advisory Speeds (VAS) and Variable Speed Limits (VSL)*

   Variable speeds systems provide advisory or regulatory speed limits to travelers on roadways approaching areas of congestion or inclement weather, increasing the safety of the roadway. This practice has the added benefit of reducing fuel consumption and maintaining smooth traffic flow. This application is currently in place on Oregon Route 217 and the southern I-5/I-205 interchange in Portland. In a connected environment, the real-time advisory speed information could be delivered directly into the vehicle, and the real-time speed data collection, which ODOT currently collects with roadway sensors, could be supplemented with data from vehicles traveling the roadway.

5. *Adaptive Ramp Metering*

   Adaptive ramp metering facilitates smooth freeway traffic flow by varying the timing of the signals that control traffic at entrance ramps based on current traffic conditions. When high density waves pass the road segment near a ramp meter, the timing is adjusted to decrease the influx of vehicles, keeping traffic density below the critical levels at which traffic flow breaks down. Current systems provide this service through in-road sensors. This application is currently deployed on many Portland area freeways and Oregon Route 569 in Eugene. In a connected environment, the traffic flow information, which ODOT currently collects with roadway sensors, could be supplemented with data from vehicles traveling the roadway.

6. *Emergency Vehicle Preemption (EVP)*

   Traffic signal preemption allows for the interruption of normal operation at an intersection to allow an emergency vehicle (EV) to pass through quickly and safely. Equipped traffic signals cycle immediately after receiving the signal from an approaching EV (following normal programmed delays for signal changes and crosswalk countdowns) and grant right-of-way to the EV. Two methods are currently implemented in Oregon: the most common system uses a directional infrared broadcaster on EVs that triggers a sensor installed in equipped traffic signals, less common uses on-vehicle GPS and mobile radios to transmit vehicle position and direction to fixed radios at traffic signals. This application is currently deployed on most traffic signals in Oregon. In a connected environment, the communication between the emergency vehicle and the roadside could use a shared dedicated short range communications (DSRC) radio that informs other vehicles near the intersection that an emergency vehicle is approaching.

7. *Transit Signal Priority (TSP)*

   Transit signal priority refers to adjustments of signal timings that act to reduce dwell time for transit vehicles. These can be operated by either be the extension of green lights to allow approaching vehicles to pass or providing an early green light by shortening the red lights to let stopped vehicles continue sooner than otherwise. TSP differs from EV preemption in that it only modifies normal operation to accommodate transit vehicles, whereas preemption interrupts the normal process for a special event. This application is currently deployed on many traffic signals in the Portland area. In a connected environment, the communication between the transit vehicle and the roadside could use a shared dedicated short range communications (DSRC) radio that coordinates priority and preemption events between other modes.

8. *Freight Signal Priority (FSP)*

   Heavy freight vehicles need more distance to stop and are slow to accelerate from a red light, which can result in local traffic congestion. Freight signal priority allows for the extension of green light cycles to minimize the stopping of heavy vehicles in the dilemma zone and reduce the number of stop/starts required for these vehicles to travel through signalized networks. This application is currently deployed at key traffic signals on freight corridors. In a connected environment, the communication between the heavy freight vehicle and the roadside could use a shared dedicated short range communications (DSRC) radio that coordinates priority and preemption events between other modes.

9. *Curve Speed and Weather Warning Systems*

   A curve speed and weather warning system provides advisory speed information at a geometric curve based on individual vehicle speeds or on current weather conditions. Using radar and pavement weather sensors, the system can estimate a suitable speed for the curve and display an appropriate warning on an electronic sign. With the addition of traffic sensors, targeted messages could be presented to vehicles approaching at excessive speeds. Curve weather warning applications are currently deployed at ramps of the OR 217/US 26 and OR 217/I-5 interchanges in Region 1, but these do not incorporate individual vehicle speeds. ODOT also operates five curve speed warning systems in Regions 3 and 5, but these do not incorporate weather information. In a connected environment, the data ODOT currently collects with roadway sensors like speed, weather, and roadway information, could be supplemented or replaced by data from connected vehicles traveling the roadway.

10. *Electronic Payment Services*

    This is a broad category of automated payment systems in which a system installed within a vehicle communicates with nearby infrastructure to register a vehicle's presence. This information is used to collect fees for various applications such as gas excise tax, mileage driven tax, parking fees, or tolls. ODOT has recently implemented an opt-in Road Usage Charge Program, OReGO, which uses electronic payment services.

11. *Snowplow Telematics*

    ODOT is currently piloting a program to track winter maintenance activities, such as snowplowing, gravel, and deicer applications. This program records data on where and when these safety measures have been deployed, enabling more efficient winter services and a record of maintenance actions, useful in tort lawsuits. Similar technology could be useful in applying herbicide, roadside mowing, or line striping maintenance.

12. *Fleet Fuel Monitoring*

    Currently, ODOT's Bulk Fuel Sensor Program involves magnetic cards, each corresponding to a specific ODOT fleet vehicle, which is used at fuel pump sites when that vehicle is being refueled. These access a database that stores information about the vehicle (mileage, engine data, maintenance history, etc.). A transition to wireless technology is planned for the future, where the vehicle automatically exchanges the data as it pulls up to the pump.

13. *Signal Phase and Timing (SPaT)*

    If a driver is stopped at or approaching a signalized intersection, information on the timing of the signal phases can aid in decision making, increase safety, and reduce driver stress. This application is currently deployed in Oregon through a third-party smartphone application called EnLighten, developed by Connected Signals, which is capable of receiving SPaT data directly from the agency's central system. ODOT is currently working with Traffic Technologies Solutions to implement a SPaT data dissemination application connected to ODOT's central signal servers.

Connected and Automated Vehicles Issues

The emergence of connected and automated vehicle technologies is advancing at a rapid rate with announcements and developments occurring daily. There are many questions that remain to be answered about legislation and long-term planning for the impacts of automated vehicles, but these are outside the scope of this document. On the other hand, there are many outstanding technical challenges that will affect transportation agencies in deploying vehicle-to-infrastructure (V2I) technology that are addressed in this operational concept including:

- Standards adoption – Are the standards ready for implementation?
- Communication technologies – Will the DSRC frequency band be preserved?
- Security Needs – How will privacy be preserved in a connected vehicle environment?
- Internet Protocol Version 6 (IPv6) Readiness – What is the Impact to Existing Agency Networks?
- Limited budgets – How will CAV technology deployments be funded?

Standards Adoption – Are the Standards Ready for Implementation?

The interoperability of regional systems is crucial to the communication on which a connected transportation system relies: Vehicles regularly travel to other cities and states, and their on-board systems need to be able to communicate reliably regardless of location. To this end, included in the Connected Vehicle Reference Implementation Architecture (CVRIA) are standards that establish a nationwide protocol structure for DSRC communications. The core standards are discussed below:

SAE International

SAE is currently contracted with FHWA to develop ITS standards related to DSRC. There are two main sets of standards being developed. SAE J2945 Dedicated Short Range Communications (DSRC) Common Performance Requirements is a collection of standards defining the radio interface, performance, and environmental requirements for specific applications. SAE J2735 Dedicated Short Range Communications (DSRC) Message Set Dictionary is designed to support interoperability among DSRC applications through the use of standardized message sets, data frames and data elements. This standard provides information that is useful in understanding how to apply the various DSRC standards, along with the message sets, data frames and data elements, to produce interoperable DSRC applications. It defines message formats for an a la carte message, basic safety message, emergency vehicle alert message, generic transfer message, a probe vehicle data message and a common safety request message.[50]

Institute of Transportation Engineers (ITE) Advanced Transportation Controller (ATC) Application Programming Interface (API)

ITE provides an open architecture standard for traffic signal controller hardware and software to support ITS applications. The API standard defines the software platform and interfaces for the cabinet’s field I/O devices and the controller’s real-time clock. This standard provides a consistent interface for developers of connected vehicle applications operating on the ATC platform.

National Transportation Communications for ITS Protocol (NTCIP)

NTCIP infrastructure standards primarily define the interfaces between ITS equipment and roadside DSRC radios. Certain connected vehicle applications may utilize these standards to issue commands or status requests to roadside ITS devices. Relevant NTCIP standards include:

- NTCIP 1202 Object Definitions for Adaptive Signal Control (ASC)
- NTCIP 1204 Environmental Sensor Station (ESS) Interface Standard
- NTCIP 1209 Object Definitions for Transportation Sensor Systems (TSS)
- NTCIP 1211 Objects for Signal Control and Prioritization (SCP)
- NTCIP 1213 Object Definitions for Electrical and Lighting Management Systems (ELMS)

IEEE 1609 Family of Standards

The IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE) defines the architecture, communications model, management structure, security mechanisms and physical access for high speed (up to 27 Mb/s) short range (up to 1000m) low latency wireless communications in the vehicular environment. The primary architectural components defined by these standards are the On Board Unit (OBU), Road Side Unit (RSU), and WAVE interface.

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[50] U.S. Department of Transportation, Research and Innovative Technology Administration, ITS Standards Fact Sheets, https://www.standards.its.dot.gov/Factsheets/Factsheet/71

IEEE 802.11 Wireless Local Area Network Standards

The US DOT supported the completion of the IEEE 802.11p amendment to the IEEE 802.11 standard along with the connected vehicle-centric IEEE 1609 series of standards to add wireless access in vehicular environments (WAVE) capability. 802.11p permits the fast link setup critical to enable many connected vehicle technologies. 802.11p is now part of the latest IEEE 802.11 standard.

Communication Technologies – Will the DSRC Frequency Band Be Preserved?

DSRC is a frequency band specifically designated by the Federal Communications Commission for high-speed/low latency automotive information transmissions. The low latency and fast network acquisition attributes of DSRC are well-suited to collision avoidance and other safety-related vehicle-to-vehicle (V2V) applications, and many of the priority CV applications defined by ODOT could benefit from DSRC for V2I communications. In the US, a 75 MHz band of spectrum in 5.9 GHz frequency range is allocated for DSRC. While the frequency band is currently dedicated for only DSRC use, there are proposals to allow private use as long there is no interference with CV communications. On February 2, 2016, the U.S. Department of Transportation released an assessment of the status of DSRC to enable connected vehicle technologies and applications.[51] The assessment found that DSRC is ready for deployment.

Although DSRC has been declared ready for deployment, there is a current proposal within the IT and telecommunications industries to share the DSRC frequency band with unlicensed applications. The 5.9GHz frequency band is considered “valuable real estate” in the radio spectrum world because it is directly adjacent to the 5.8GHz band that comprise much of the unlicensed band covered under IEEE 802.11a standards and commercially known as Wi-Fi. Testing is currently underway to demonstrate the feasibility of this proposal to share the band with unlicensed, non-connected vehicle applications.[52] The current testing seeks to demonstrate that non-safety messages can vacate the frequency band when higher priority safety messages are occurring.

Because of this current testing, there is some uncertainty about the future of DSRC. But, at the time of authoring this operational concept, decisions by the FCC and other regulatory bodies remain up in the air about the long-term dedication of DSRC to the transportation industry.

ODOT is likely to implement DSRC primarily for vehicle to infrastructure applications that require high speed communications such as Signal Phase and Timing (SPaT), pedestrian in cross walk, and work zone applications. Many other CV applications are not dependent on DSRC to be fully implemented and will rely on a variety of technologies, including cellular service, and Wi-Fi. The majority of priority ODOT applications can be supported equally by standard cellular and Wi-Fi communications.

The majority of vehicles on the roadway today are not equipped with DSRC radios that will be required to communicating with radios on the roadside. Original equipment manufacturers (OEMs) are expected to begin installing on board units (OBUs) for DSRC on new vehicles starting in 2017, but the migration path to wide deployment on the vehicle fleet will take an extended period of time. For that reason, early deployments using DSRC for communications to

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[51] U.S. Department of Transportation News Update, Assessment of Communications Technology for Connected Vehicles, February 2, 2016 http://campaign.r20.constantcontact.com/render?ca=8bc02739-fc43-49a8-9b58-ff1656d70cf6&c=77da6f90-5104-11e3-8e6b-d4ae52a4597c&ch=7a7c1c80-5104-11e3-8e6c-d4ae52a4597c

[52] DSRC-Unlicensed Device Test Plan, August 2015. http://www.its.dot.gov/connected_vehicle/pdf/DSRC_TestPlanv3.5.3.pdf

the roadside will likely be limited to cases that support communications from public agency fleets or transit vehicles to the roadside. Deployments sharing connected vehicle information with other third party information providers will use other methods for delivering information to the vehicle such as cellular or Wi-Fi.

Security Needs – Data Confidentiality, Integrity, and Availability in a Connected Environment

Safe operation of a connected vehicle system depends on a security and communications network that can ensure the source of each message can be trusted, and that the message content can be protected from outside interruption. Creating this trusted environment requires a security system that can credential each message, and a communications network that can deliver the security credentials to entities verifying the system security.

For that reason, the USDOT is leading the development of a Security Credential Management System (SCMS), which provides a concept and framework for ensuring secure communications between connected elements in a connected vehicle environment. SCMS processes are applicable for all connected vehicle communications, whether DSRC-based, cellular, or Wi-Fi, that are sharing critical safety information between the devices on the roadside or in vehicles. SCMS will not be necessary for some applications including broadcast applications such as traveler information or for transmitting the aggregated data obtained from the roadside unit and the local traffic management center.

Key objectives of the SCMS are to ensure messages are genuine, accurate, from a trusted sender, and non-personally identifiable. Certificate granting and revocation authority for enrollment, pseudonyms, authorization, and applications originates from the SCMS Certificate Authority, as illustrated in the figure below.

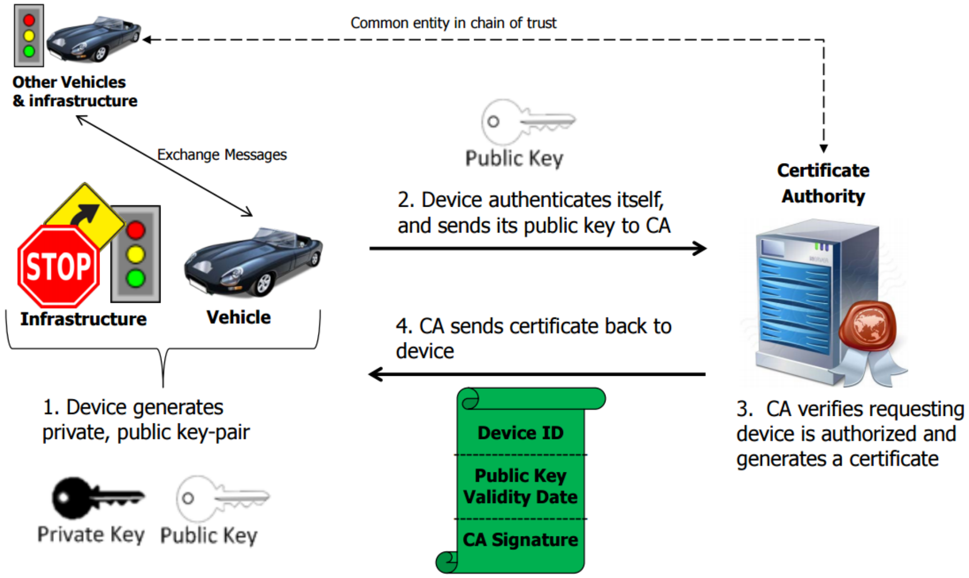

Figure 27. SCMS Public Key Certificate Granting Process.[53]

At the time of authoring this operational concept, much work is still underway on the SCMS process and whether the private sector or public sector will be responsible for the process.

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[53] Source: USDOT CV Pilot Deployment Program, Preparing a Security Operational Concept for Connected Vehicle Deployments, December 15, 2015

NHTSA anticipates the private sector will be responsible for creating and managing the security certificates, but there is not a current private entity taking the lead. For roadside information, DSRC/RSU vendors are building in security credentials and public/private keying and are likely candidates for addressing the security at the RSU, which may ultimately be certified and qualified by a national laboratory. For traveler information, ODOT will likely continue to provide data to a message broker, such as TTIP, and the private sector or a national/regional message broker may subscribe to the data and have security credentials to provide the information to the vehicle.

Internet Protocol Version 6 (IPv6) Readiness – What Is the Impact to Existing Agency Networks?

The emergence of connected vehicles means there will be more and more IP addressable devices on the vehicle and on the roadside, which requires enough IP addresses to support the expanding quantity of networked devices. Connected vehicles also rely on high speed, reliable communications between the vehicle and the infrastructure, or vehicle to vehicle, or vehicle to other such as pedestrians and bicycles. This section describes why IPv6 is required for connected vehicle applications, what the implications may be for ODOT's existing network infrastructure, and ODOT's capability to support IPv6.

IPv6 will be necessary for connected vehicle applications for a number of reasons:

1. IPv6 provides an almost unlimited number of IP addresses, which makes it the ideal choice for deploying a large number of new devices[54]
2. IPv6 has integrated quality of service (QoS) capabilities, which means reliable audio and video transmission are possible
3. Internet connectivity using IPv6 is expected to transmit information at 40 Gb/s

ODOT networks and devices currently utilize the IPv4 protocol, and it is unlikely that ODOT will transfer from IPv4 to IPv6 instantaneously. However, equipment vendors have begun preparing for the inevitable migration to IPv6. Many are supporting firmware upgrades or have embedded the capability today. For the RuggedCom/Siemens field network equipment used by ODOT, the modifications should be minimal. The existing ROS1 products (RS900, RS930L, etc.) will be capable of supporting IPv6 with a firmware update expected in early 2017. The ROS2 products (RX1500, RX1400) and Cisco equipment used by ODOT are already compliant with IPv6. An impact outside of ODOT's immediate control is the dependence on DAS networking infrastructure and the department's timeline to migrate to IPv6.

Limited Budgets – How Will CAV Technology Deployments Be funded?

Funding connected vehicle deployments and DSRC remains voluntary and many questions remain about how deployments with DSRC radios will be funded, deployed and maintained. Implementation of several pilot projects around the country are currently underway, and many transit agencies are expressing interest to improve transit operations at intersections. Although, planning, deployment, and implementation remain in the early stages the USDOT has invested heavily in recent pilot deployments through some national grant opportunities that have emphasized DSRC deployment. The recent significant grant opportunities including some that have not been decided include:

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[54] IPv4 uses a 32-bit IP address, which provides near 3.7 billion usable IPv4 addresses. For comparison, the current world population is about 7.4 billion. IPv4 will not sustain the ever increasing number of IP addressable devices. In contrast IPv6 uses a 128-bit IP address, which provides an address space near 3.4 *10^{38} addresses.

Grants with submittals closed

- Wave 1 Connected Vehicle Deployment Grant – Awarded three implementations with a total of $42 million
- Smart City Challenge - $50 million

Expected USDOT grant opportunities

- Wave 2 Connected Vehicle Deployment Grant – Expected in 2017

ODOT's Vision for Priority Connected and Automated Vehicles Applications

ODOT has done considerable work in assessing the wider connected and automated vehicle application landscape and identifying those applications that best address the goals and needs of the transportation system for which ODOT is responsible. This effort began with ODOT's 2015 Intermodal Leadership Team CAV Strategic Framework and application prioritization initiative. From this initiative, ODOT identified 26 connected vehicle applications for which the agency has some interest and categorized them according to ODOT's potential leadership role in their development. The priority applications were compiled from the Connected Vehicles Pilot Deployment Program applications[55]. However, the USDOT has also developed the Connected Vehicle Reference Implementation Architecture (CVRIA), which aligns with the National ITS Architecture and has a slightly different set of applications[56]. The connected vehicle applications and prioritizations are shown in Table 22 below:

Table 22. Connected Vehicle Application Prioritizations

• **Category 1 Applications (Near-term focus for ODOT and highest priority)** ○ Advanced Traveler Information System (EnableATIS) ○ Dynamic Speed Harmonization (SPD-HARM) ○ Freight Dynamic Travel Planning & Response ○ Signal Phase and Timing (SPaT) ○ Curve Speed Warning ○ Probe-enabled Traffic Monitoring ○ Motorist Advisories & Warnings (MAW)
• **Category 2 Applications (ODOT should monitor, possibly collaborate, leadership by others)** ○ Incident Scene Work Zone Alerts (INC-ZONE) ○ Work Zone Traveler Information ○ Advanced Traveler Information System (Enable/ATIS) ○ Next Generation Ramp Metering (RAMP) ○ Eco-ICM Decision Support System ○ Congestion Pricing ○ (with road user charge) ○ SPOT Weather Impact Warning ○ Disable/Oversized Vehicle Warning ○ Emergency Communications/Evacuation ○ Probe-based Pavement Maintenance ○ Enhanced Maintenance Decision Support ○ Smart Truck Parking
• **Category 3 Applications (Leadership by others, ODOT monitor)** ○ Queue Warning (Q-WARN)

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[55] http://www.its.dot.gov/pilots/cv_pilot_apps.htm

[56] http://www.iteris.com/cvria/html/applications/applications.html

  - AFV Charging/Fueling Information
  - Tolling
  - HOT Lanes
  - Railroad Crossing Warning
  - Incident Guidance Emergency Response
  - CV-enabled Performance Measures
  - Wireless Inspection

The seven high-priority (category 1) applications that emerged from this effort reflect the CV applications that showed the clearest benefit, leveraged existing ODOT investments, and aligned with established agency goals and priorities. The rationale for selection and the anticipated key benefits of the high-priority applications are discussed below.

Benefits – What Benefits Can Be expected?

The following sections describe the benefits expected from deploying the highest priority ODOT CV applications.

1. *Advanced Traveler Information System (EnableATIS)*
   Traveler information is well established as a core management strategy for ODOT and the ATIS application leverages these previous investments. ODOT's expected implementation of ATIS entails receiving data from connected vehicles, disseminating traveler information from infrastructure to equipped vehicles, and making ODOT collected data available to the private sector via the TripCheck Traveler Information Portal.

   Benefit: Traveler information dissemination supports several important agency goal areas, primarily mobility, but with secondary benefits to safety and sustainability.

2. *Dynamic Speed Harmonization (SPD-HARM)*
   A key ODOT priority is to utilize existing infrastructure in a more efficient manner. Dynamic speed harmonization as a CV application serves as an extension of ATM efforts already underway that rely on advisory variable speed limit signs above or beside the roadway.

   Benefit: Enhanced speed harmonization capabilities support the mobility, system reliability, and safety goals achieved by stabilizing traffic flow, and informing travelers of current traffic and roadway conditions. Connected Vehicles can also be used as data sources and allow systems to be less reliant on field sensors, eventually reducing system deployment and maintenance costs.

3. *Freight-Specific Dynamic Travel Planning*
   Dynamic travel planning supports the ODOT priority of reducing freight congestion and delays, which result in high economic costs. This application can include fleet route planning and permitting, such as combining vehicle permitting with route height restrictions or delivering roadside warnings when a over-height vehicle is off route. Freight-specific travel planning information would be disseminated to a limited audience of “professional” dispatch operators and third party information providers.

   Benefit: Reducing congestion encountered by goods movement has benefits for economic competitiveness as well as general mobility; sustainability is a side benefit.

4. *Signal Phase and Timing (SPaT)*
   Mobility and safety at and around intersections is a high priority for ODOT. The dissemination of SPaT data to vehicles at the intersection is one of the core capabilities of connected vehicles. Additionally, auto manufacturers have expressed strong interest in collaborating with transportation agencies on this concept. A signalized intersection is an optimal site to locate DSRC equipment due to its pre-existing power and communications infrastructure that can be leveraged.

   Benefit: Significant improvements in both safety and mobility are anticipated as a result of reduced intersection traffic signal violation crashes, smoother driving responses by drivers traversing intersections, reduced uncertainty for drivers who may have difficulty perceiving signal phases or may get caught in dilemma zones, and fewer resulting rear-end crashes. This application also serves as a support system for other connected vehicle applications such as Eco-Approach and Departure at Signalized Intersections.

5. *Curve Speed Warning*
   The connected vehicle-enabled curve speed warning application supports the ODOT safety priority and extends current efforts to provide timely and accurate curve speed warnings to motorists.

   Benefit: Increased safety through reduction in crashes.

6. *Probe-enabled Traffic Monitoring*
   Probe-enabled traffic monitoring is central to the ODOT connected vehicle business case to collect highly detailed information from the traveling fleet that can be can used to inform analytical and planning processes.

   Benefit: Provides a significant supplement and enhancement to the ODOT data capture program that can be used to inform and enhance other processes.

7. *Motorist Advisories & Warnings (MAW)*
   Motorist advisories and warnings support ODOT's safety goal and leverages existing investments in traveler information channels to disseminate advisories and warnings to motorists.

   Benefit: MAW represents an opportunity to help drivers avoid unsafe or otherwise undesirable conditions.

Physical Architecture – System Objects and Interfaces

The following sections explore the physical architectures for each connected vehicle application and are tailored to ODOT's existing architecture and systems. These diagrams show the physical objects, such as systems or devices, and the interfaces with information data flows needed to support a particular application. Physical objects are classified by infrastructure type: center (teal), field (orange), vehicle (blue), traveler (yellow), or support (green). Data flows are displayed with cardinality and security needs: unauthenticated clear data (black), unauthenticated encrypted data (blue), authenticated clear data (green), and authenticated encrypted data (red). Many applications show redundant data flows, highlighting different ways the connected vehicle application could be deployed.

1. *<u>Advanced Traveler Information System (EnableATIS)</u>*
   Traveler information distribution is focused around ODOT's TTIP. Information from ODOT, other centers, support system, and commercial data providers is collected and disseminated to travelers and vehicles through RSE and commercial information service providers (CISPs).

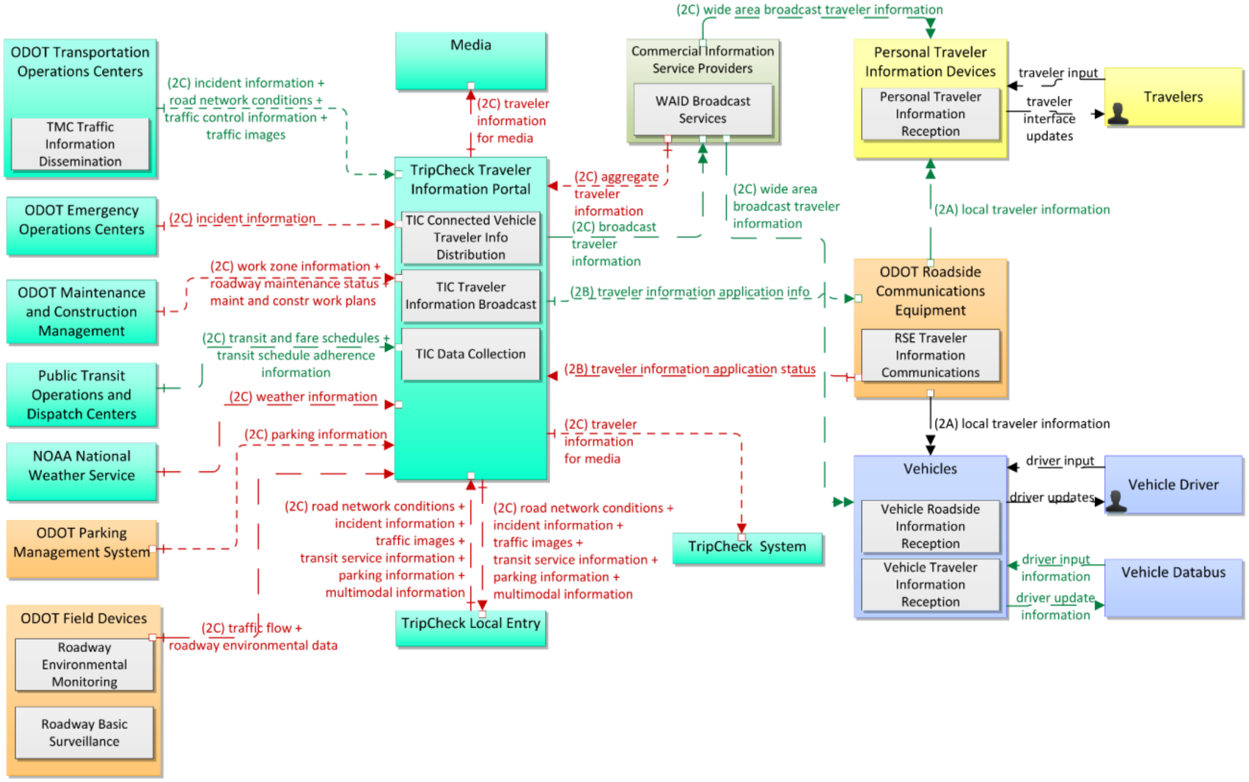

Figure 28. Advanced Traveler Information Systems Physical Diagram.

2. *Dynamic Speed Harmonization (SPD-HARM)*
   Variable speed systems can be managed by traffic and environmental data received from Agency field devices, as well as from connected vehicles themselves. This allows ODOT to augment existing systems with additional data sources. In addition to roadside dynamic signs, status of variable speed zones can be distributed directly to connected vehicles through future RSE and CISPs via TTIP.

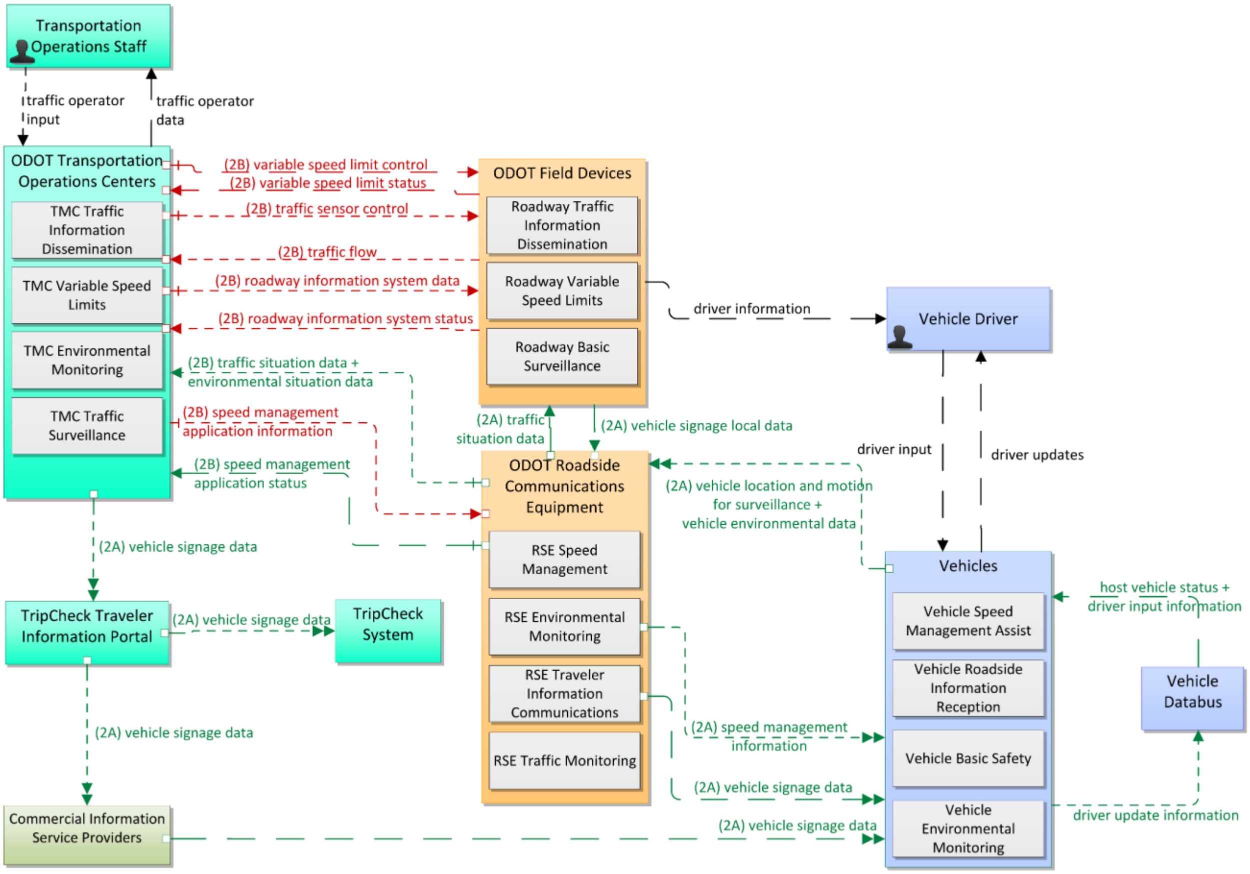

Figure 29. Variable Speed Physical Diagram.

3. *Freight-Specific Dynamic Travel Planning*
   ODOT's role in freight planning is primarily to use TTIP as an information conduit to provide information from ODOT centers and systems to commercial vehicle dispatchers and operators.

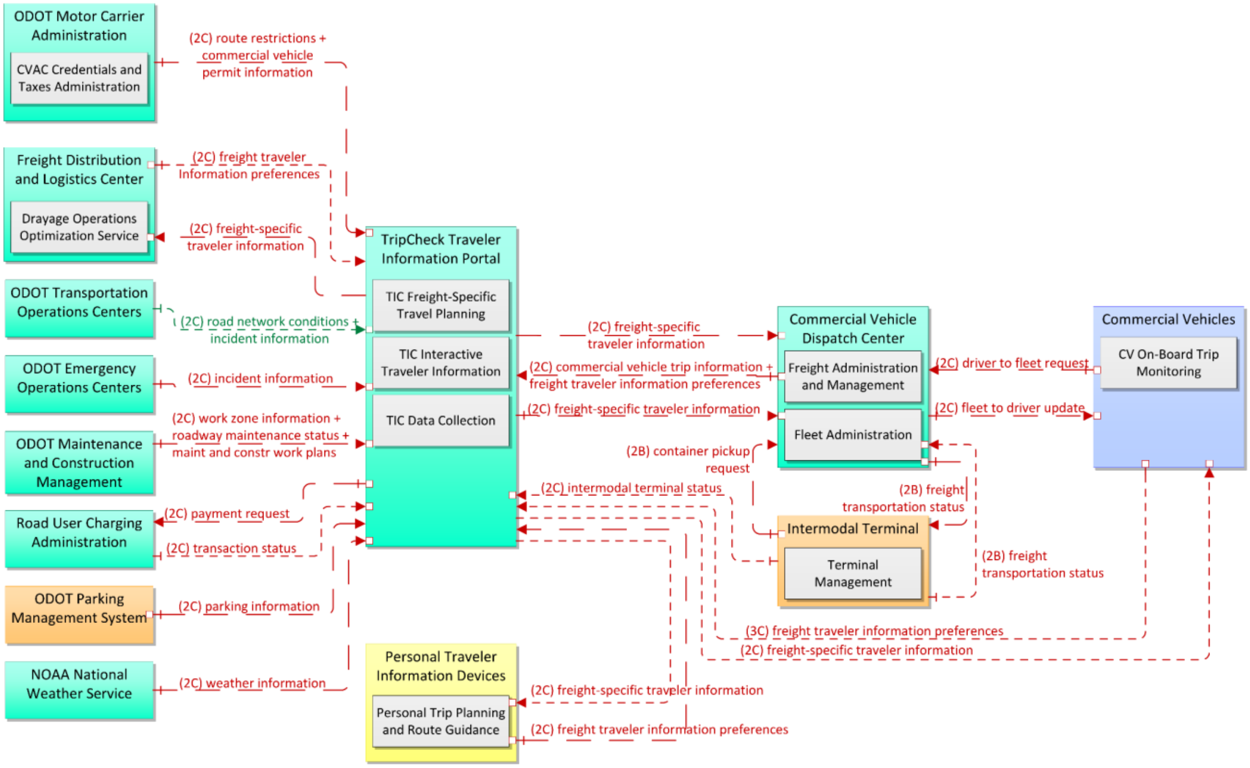

Figure 30. Freight-Specific Dynamic Travel Planning Physical Diagram.

4. *Signal Phase and Timing (SPaT)*
   Signal phase and timing primarily integrates ODOT's traffic signal control system with vehicles through either future RSE or CISPs. The roadside communications equipment can also be used to collect vehicle data to augment vehicle detection and further optimize signal operations.

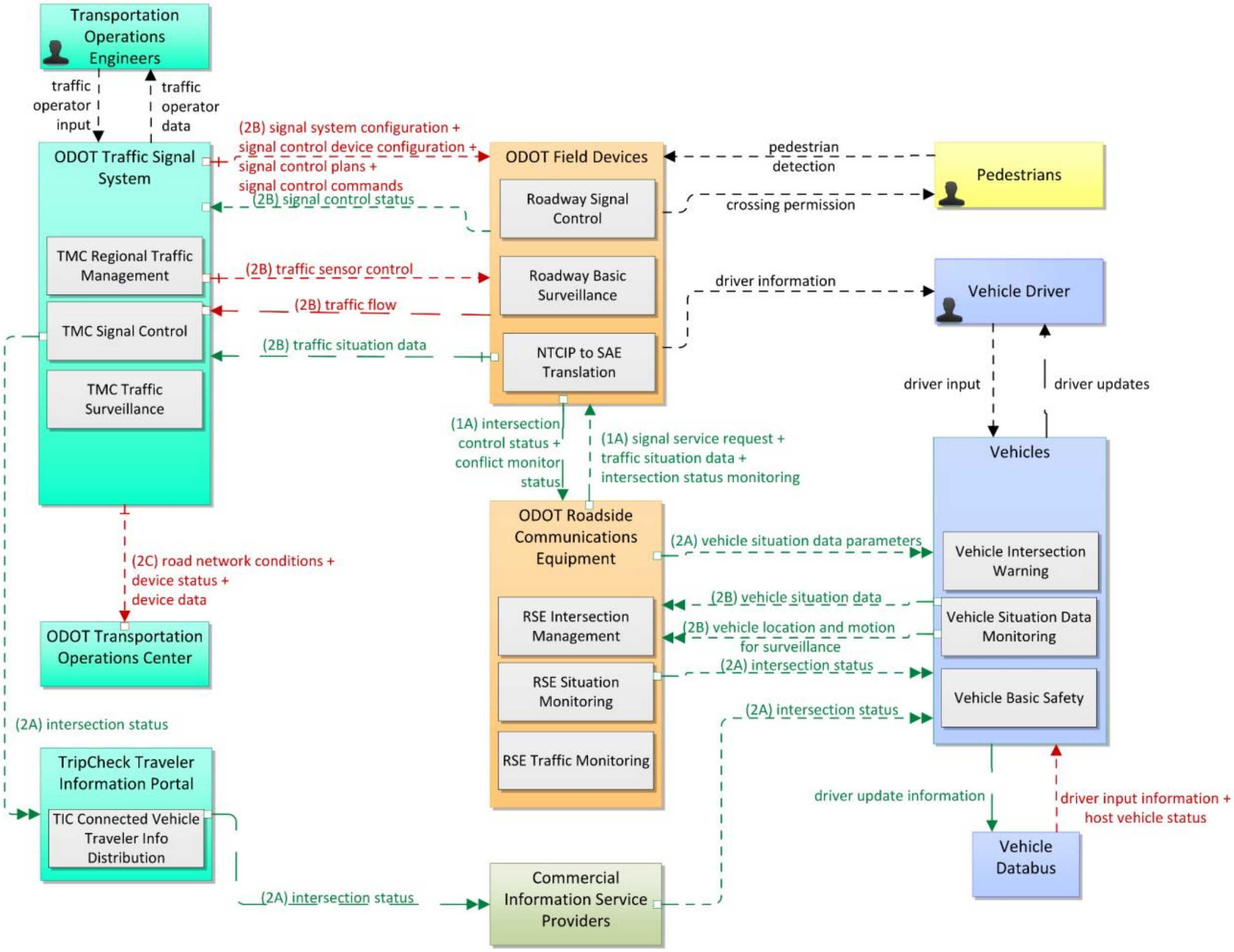

Figure 31. Signal Phase and Timing Physical Diagram.

5. *Curve Speed Warning*
   The curve speed warning system integrates environmental sensor data and speed monitoring to provide tailored speed notifications to connected vehicles. While the figure below shows the data connection and warnings through a center, this application could also be potentially deployed as a standalone roadside unit.

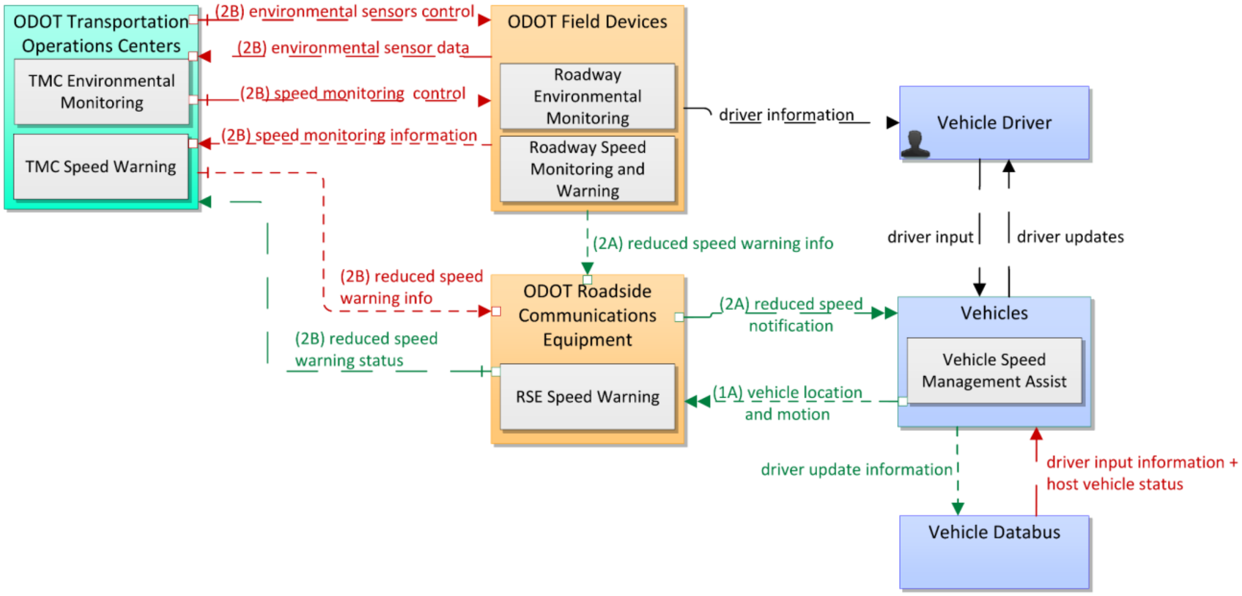

Figure 32. Curve Speed Warning Physical Diagram.

6. *Probe-enabled Traffic Monitoring*
   Probe-enabled traffic monitoring focuses on the backend center systems for collecting and archiving connected vehicle data received from RSE for future analysis.

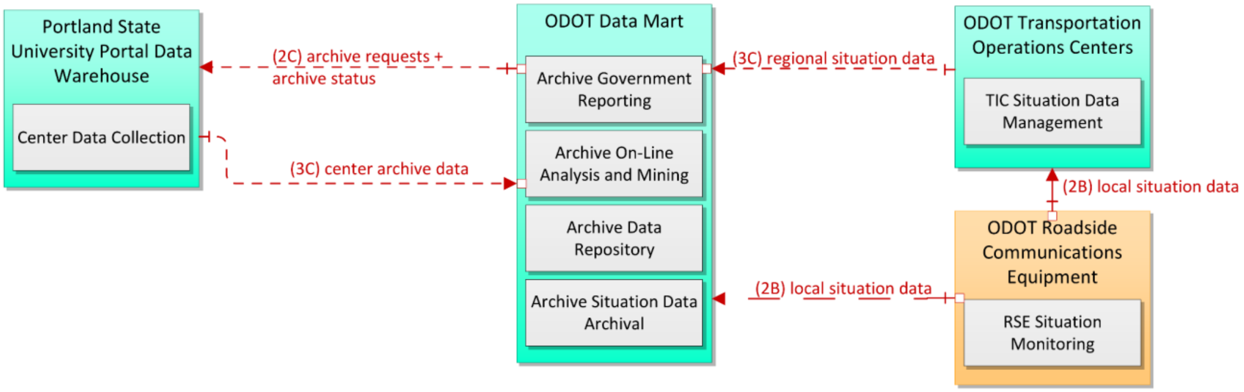

Figure 33. Performance Monitoring and Planning Physical Diagram.

7. *Motorist Advisories & Warnings (MAW)*
   The motorist advisories and warnings application integrates many different systems. The focus is largely on the distribution of road weather alerts to drivers and maintenance staff, primarily through ODOT RSE or CISPs. The application can also support the collection of vehicle environmental data to further augment existing weather information systems.

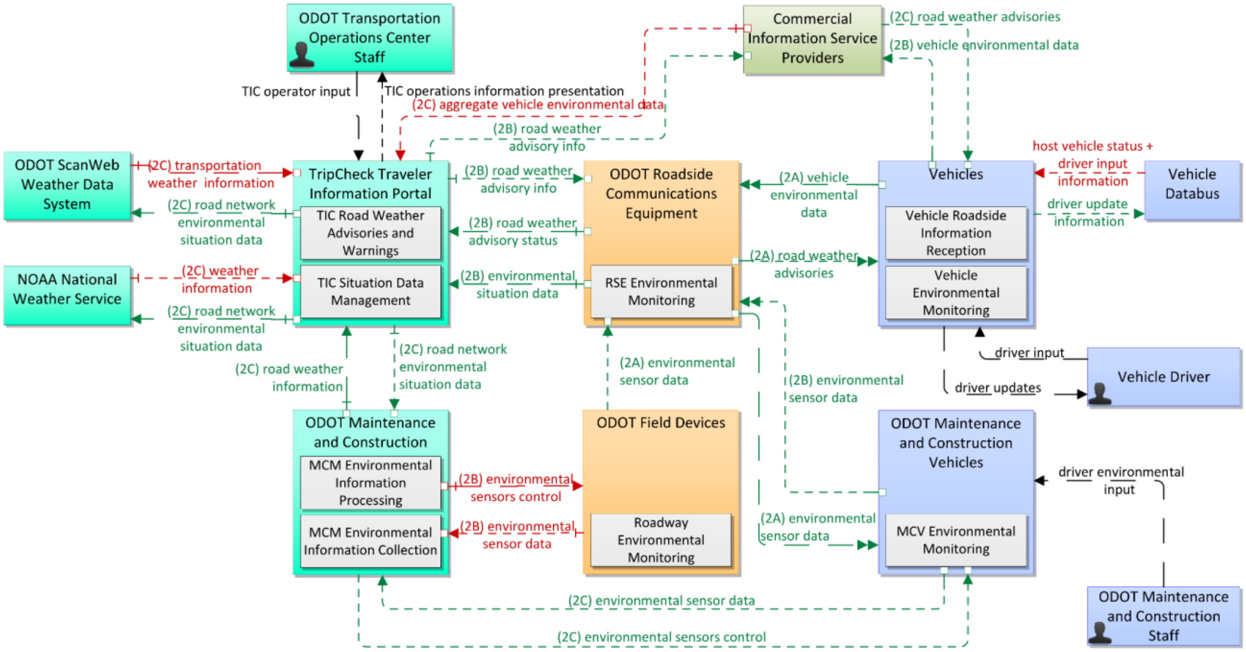

Figure 34. Road Weather Advisory and Warnings Physical Diagram.

Leveraging USDOT CV Application Development Resources

ODOT can benefit from incorporating the application development tools and other resources produced by the USDOT connected vehicle research program into its own CV deployment plans. One particularly valuable resource is the Connected Vehicle Reference Implementation Architecture (CVRIA), which provides a foundational tool for assessing the relevance of CV applications to a region and guidance for the regional transportation agency to accomplish its goals.

Priority Application Use Cases

Four operational use cases have been developed to illustrate how the seven ODOT high-priority CV applications will be utilized in a typical operational environment. These use cases are:

1. Curve Speed Warning
2. Rural Freeway Weather Incident
3. Freeway Active Traffic Management
4. Traffic Signal Timing and Operations

Table 23 shows how the seven priority applications map to each of the illustrative use cases.

Table 23. Use Cases by Priority Application

Priority Application	**Use Case 1:** Curve Speed Warning	**Use Case 2:** Rural Freeway Weather Incident	**Use Case 3:** Freeway Active Traffic Management	**Use Case 4:** Traffic Signal Timing and Operations
Advanced Traveler Information (EnableATIS)	**x**		**x**	
Dynamic Speed Harmonization (SPD-HARM)			**x**	
Freight Dynamic Travel Planning & Response		**x**		
Signal Phase & Timing (SPaT)				**x**
Curve Speed Warning	**x**			
Probe-enabled Traffic Monitoring			**x**	
Motorist Advisories & Warnings (MAW)	**x**	**x**	**x**	

Use Case 1: Curve Speed Warning

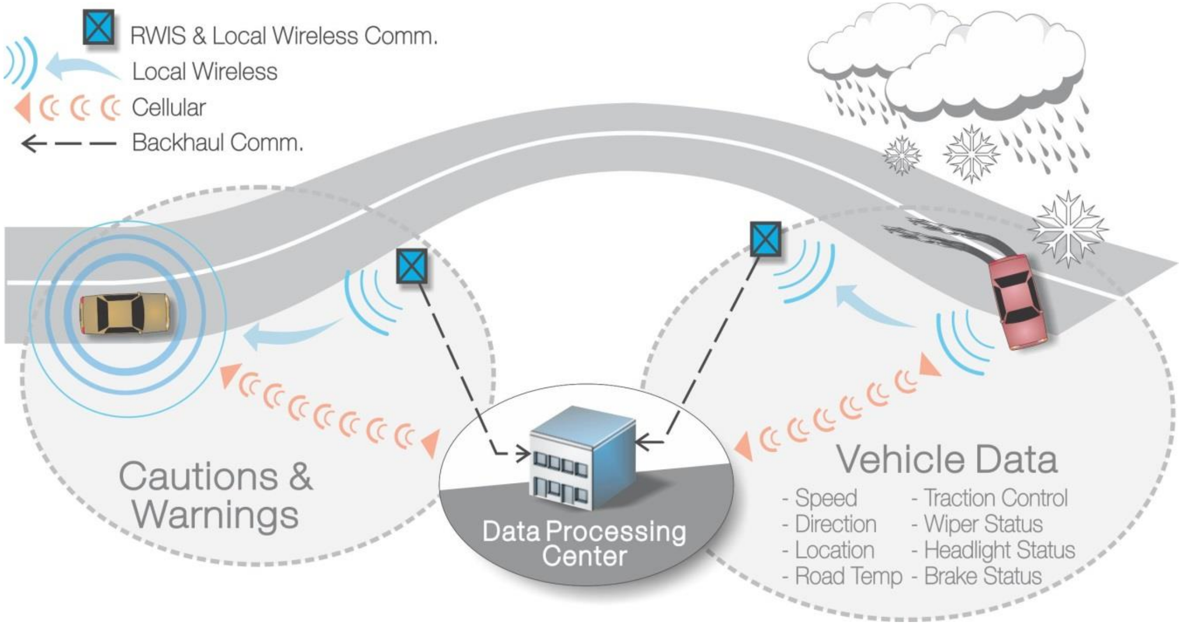

Figure 35. Example Curve Speed Warning

A curve speed warning uses recent data to determine the appropriate advisory speed for a geometric curve based on current weather conditions. This advisory speed is calculated using local data from Agency environmental sensor stations (ESS) and from on-board equipment that monitors and reports the speed and traction control system status of vehicles that have recently traversed the curve. Speed advice can be provided to drivers as general advisory messages or as targeted warnings to those vehicles exceeding the recommended speed.

Stakeholders

- Drivers
- Freight operators
- Agency winter maintenance
- Agency ITS maintenance
- Agency operations staff

Expected Benefits

- Reduced crashes
- Reduced post-crash congestion
- Probe vehicle data augmentation of Agency ESS, helping prioritize winter maintenance activities

Improvement Metrics

- Crash rate
- Travel time and delay
- Time from detection of dangerous conditions to maintenance action

Relevant CVRIA Applications and Readiness (Challenging: ○, Simple: ●)

Curve Speed Warning (CSW)	◕
Road Weather Motorist Alert and Warning (MAW)	◑
Spot Weather Impact Warning (SWIW)	◔

Use Case 2: Rural Freeway Weather Incident

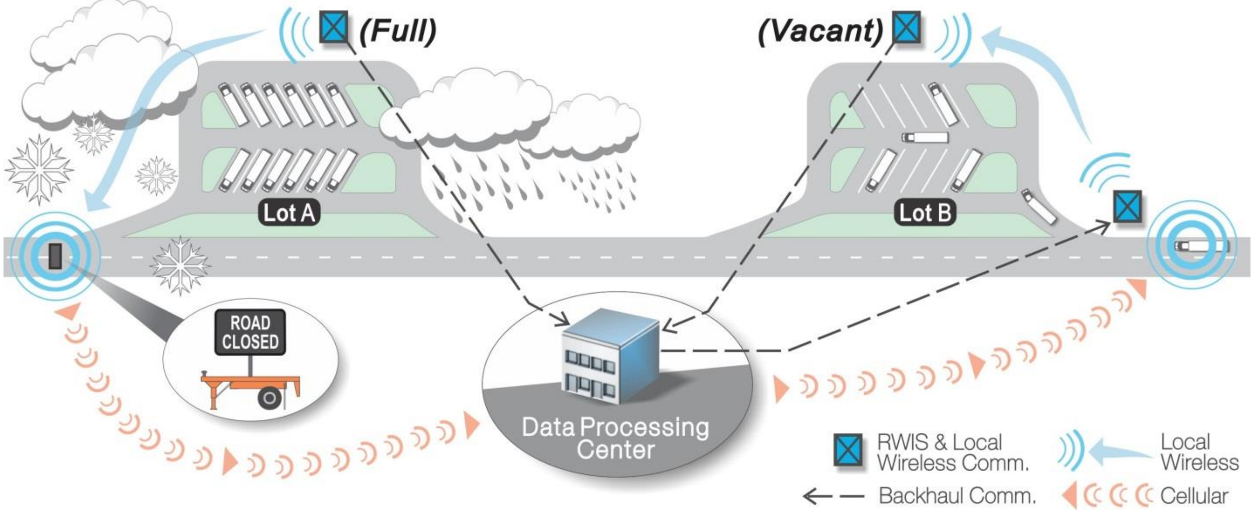

Figure 36. Example Rural Freeway Weather Incident

A rural freeway weather incident reporting system uses connected vehicle data to collect and analyze road weather data for the purpose of facilitating maintenance activities and informing travelers. Early warnings can be distributed to road users when a road is expected to close due to worsening weather conditions. With these warnings, drivers can adjust their route choice and travel plans accordingly. In rural areas, freight carriers often may not have alternate routes nearby. In the example depicted above, a weather incident reporting system works in tandem with a Smart Parking application. Truck drivers are informed of downstream inclement weather in time to access parking facilities that are not filled to capacity. This avoids the return trips required if parking availability can only be assessed after arriving at the full lot, saving time and frustration.

Stakeholders

- Drivers
- Freight operators
- Agency winter maintenance and ITS maintenance staff
- Agency operations staff

Expected Benefits	*Improvement Metrics*
Reduced crashes	Crash rate
Reduced post-crash congestion	Travel time and delay
Reduced unnecessary rerouting	VMT, trucker satisfaction
Reduced staff required to direct traffic	Staff-hours available for other work

Relevant CVRIA Applications and Readiness (Challenging: ○, Simple: ●)

Advanced Traveler Information Systems (ATIS)	◕
Freight-Specific Dynamic Travel Planning	◔
Road Weather Information for Freight Carriers	◕
Road Weather Information for Maintenance and Fleet Management	◑
Road Weather Motorist Alert and Warning (MAW)	◑
Spot Weather Impact Warning (SWIW)	◔

Use Case 3: Freeway Active Traffic Management

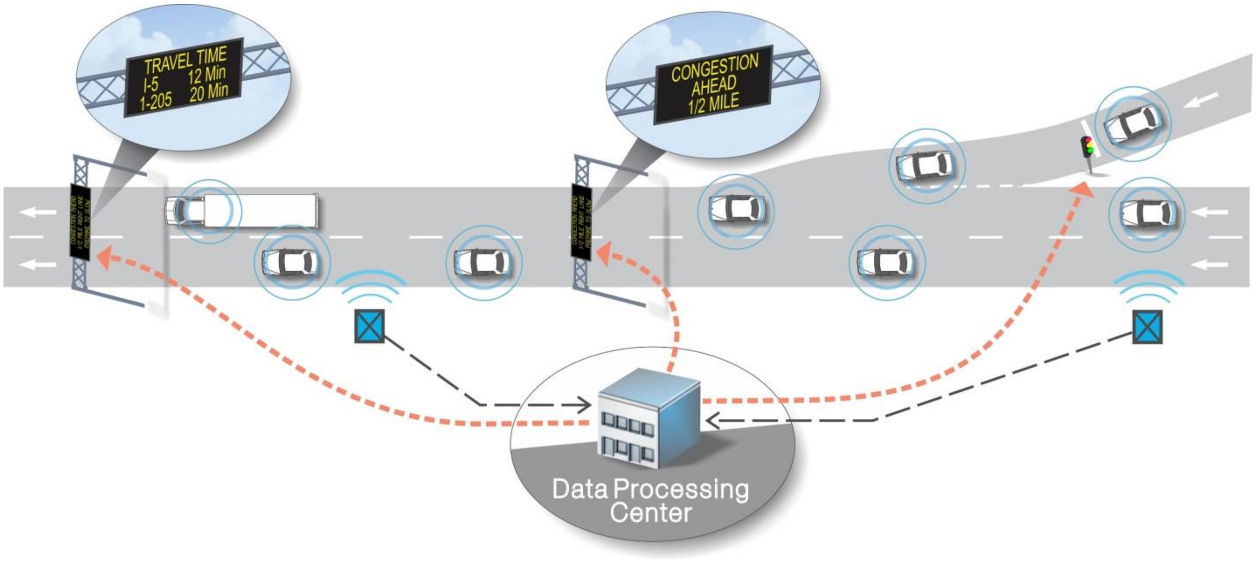

Figure 37. Example Freeway Active Traffic Management

An active traffic management system on the freeway combines many applications to facilitate better traffic operations, inform travelers, and improve system efficiency. Traveler information can be distributed to road users about expected travel times, congestion, and roadway incidents. Drivers can prepare for unusual conditions and not be surprised and anxious by sudden congestion. Operationally, eco-ramp metering and speed harmonization applications can be used to optimize traffic flow for reduced emissions or to decrease traffic speed differentials.

Stakeholders

- Drivers
- Freight operators
- Agency operations staff

Expected Benefits

- Increased safety
- Decreased emissions
- More reliable travel times

Improvement Metrics

- Crash rate and severity
- Roadside air quality
- Travel time reliability

Relevant CVRIA Applications and Readiness (Challenging: ○, Simple: ●)

Advanced Traveler Information Systems (ATIS)	◕
Eco-Ramp Metering	◕
Eco-Speed Harmonization	◑
Queue Warning(Q-WARN)	◕
Road Weather Motorist Alert and Warning (MAW)	◑
Speed Harmonization (SPD-HARM)	◕
Vehicle Data for Traffic Operations (VDTO)	◑

Use Case 4: Traffic Signal Timing and Operations Distribution

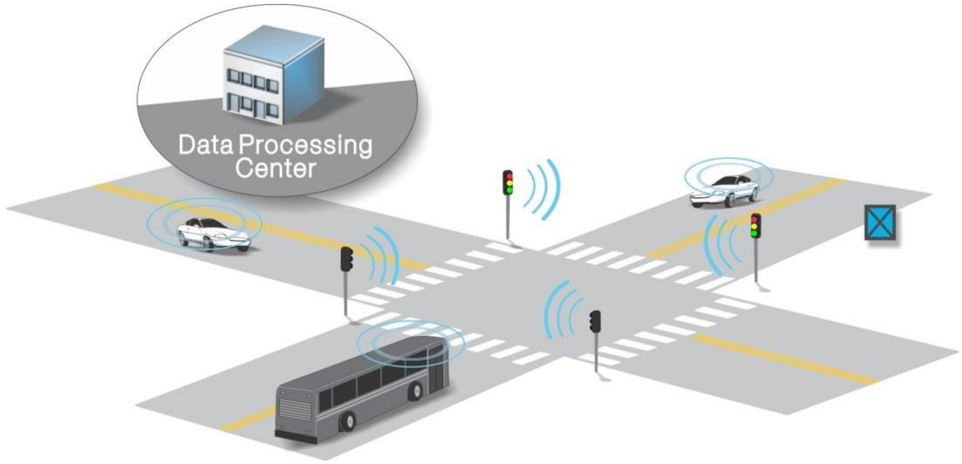

Figure 38. Example Traffic Signal Timing and Operations Distribution

Connected traffic signals can provide information on the current phasing and timing to drivers and allow support other operational applications. As a vehicle approaches a traffic signal, the signal phase and timing can notify the driver if the light will turn yellow or red before they arrive, allowing the driver to slow down and travel in the coordinated green band. This same technology can also support preemption events from emergency vehicles and priority requests from transit vehicles and heavy freight vehicles.

Stakeholders

- Drivers
- Freight operators
- Transit
- First Responders

Expected Benefits

- Improve intersection efficiency
- Improve safety
- Improve fuel economy
- Improve driver happiness

Improvement Metrics

- Intersection delay
- Percent vehicles arrival on green
- Crash rate
- Crash severity
- Roadside air quality

Relevant CVRIA Applications and Readiness (Challenging: ○, Simple: ●)

▪ Emergency Vehicle Preemption (EVP)	◑
▪ Freight Signal Priority (FSP)	◑
▪ Pedestrian Mobility	◔
▪ Red Light Violation Warning (RLVW)	◔
▪ Signal Phase and Timing (SPaT)	◕
▪ Transit Signal Priority (TSP)	◑

Stakeholder Roles and Responsibilities

Many political and institutional decisions still need to be made before defining specific connected and automated vehicle roles and responsibilities. Table 24 describes the typical roles and responsibilities for initial stakeholders.

Table 24. Connected and Automated Vehicles Stakeholder Roles and Responsibilities

Stakeholder	Roles and Responsibilities	Status
Oregon Department of Transportation (ODOT)	▪ Encourage and support using the ITS Architecture for project planning and implementation. ▪ Act as a liaison for the rest of ODOT. ▪ Design, construction, operate, and maintain connected vehicle infrastructure. ▪ Install connected vehicle roadside units (RSUs) at signalized intersections and other key points.	▪ Existing/Planned ▪ Existing/Planned ▪ Planned ▪ Planned
ODOT Information Systems Branch (ISB)	▪ Provide communications and information systems support for ODOT regional systems.	▪ Existing
	▪ Design, develop, operate, and support backend systems for connected vehicle applications.	▪ Existing/Planned
	▪ Provide and collect connected vehicle data to/from Data Clearinghouses.	▪ Planned
ODOT ITS Support Coordinators	▪ Provide support of communications equipment and connected vehicle roadside units for ODOT district maintenance.	▪ Existing/Planned
Oregon Driver and Motor Vehicle (DMV) Services Division	▪ Guide and implement policies and regulations for automated vehicles in Oregon.	▪ Future
Local Traffic Management Agencies	▪ Design, develop, and operate backend systems for connected vehicle applications. ▪ Design, construction, operate, and maintain connected vehicle infrastructure. ▪ Install connected vehicle roadside units (RSUs) at signalized intersections and other key points. ▪ Provide and collect connected vehicle data to/from Data Clearinghouses.	▪ Future ▪ Future ▪ Future ▪ Future
Travelers	▪ Provide and collect connected vehicle data to/from infrastructure (V2I) and other vehicles (V2V).	▪ Planned
Commercial Transportation Service Providers	▪ Provide and collect connected vehicle data to/from infrastructure (V2I) and other vehicles (V2V).	▪ Planned
Auto Manufacturers	▪ Install connected vehicle on board units (OBUs) in vehicles.	▪ Planned
Trusted Third Party Service Providers (TTSPs)	▪ Serve as the Connected Vehicle Clearinghouse by collecting and delivering relevant Agency data to connected vehicles. ▪ Provide value added services (e.g. traveler information) to connected vehicles.	▪ Planned ▪ Planned

Deployment Guidance

This section describes the latest understanding of the steps required to deploy a Connected Vehicle application, incorporating practices that promote efficient and effective planning, procurement, and operations throughout the lifecycle of the project. Given that the industry is still maturing, ODOT infrastructure and vehicle fleets are yet to be outfitted, and few real-world active deployments exist from which to garner insights besides a handful of pilot deployment sites around the country. Therefore, it becomes critical for the agency to monitor the latest CV developments and to incorporate lessons learned and emerging best practices as they become available.

The FHWA Vehicle-to-Infrastructure Deployment Guidance and Products document, still in development as of January 2017, seeks to provide such guidance as well as to identify applicable federal-aid programs to be made available to transportation agencies. The V2I Deployment Coalition SPaT Challenge intends to provide deployment guidance for agencies wishing to deploy DSRC for SPaT messaging. The V2I Deployment Guidance is anticipated in in the near future. While the federal guidance has not yet been published, key elements necessary to install, operate, and maintain a CV V2I deployment are already known. These elements, tailored to the needs and operational setting of ODOT, are described below.

It is important to note however that while federal guidance often assumes a DSRC-based communications infrastructure, ODOT will select the communications technology best suited to a given CV application, considering the specific objectives and operational context of the deployment. Technology may include DSRC, cellular, Wi-Fi, or other.

Infrastructure Elements

Make existing and planned ITS and signal equipment CV-ready. CV field infrastructure will often be installed in areas with existing ITS equipment, offering an opportunity to leverage existing power, cabinet space, and backhaul communications. Because CV infrastructure will need to be integrated with existing equipment, V2I communications requirements and standards should be considered when selecting and purchasing new ITS equipment and signal controllers. Other considerations for making a roadside site CV-ready include:

- Roadside equipment (RSE) – The RSE generally includes single or dual DSRC radios with GPS enclosed in weather protected enclosure with antenna(s). The RSE is suitable for mounting to an existing traffic signal, ITS, or light pole.
    - For new signal and ITS equipment designs, include extra low voltage conduit capacity to the pole nearest the cabinet for future network cables.
    - Use available reliable power from existing sites
    - Develop plans for identifying mounting locations for V2I equipment
- Backhaul communications
    - To the extent possible, establish two secure backhaul communications links—one for ITS/traffic signal data and one for CV data
    - DSRC radios need reliable and automated monitoring from central. Current pilot deployments by other agencies are using over-the-air testing to confirm radio broadcasts. This limited verification approach not acceptable for an ODOT deployment.

- Signal controller/cabinet upgrades
    - Procure Agency accepted ATC controllers. While the CV applications may need to be developed, these controllers enable CV applications without additional hardware requirements.
- Infrastructure-based messaging
    - Define electronic map or geometric description of the surrounding area available (MAP data)
    - Establish and incorporate a standard for MAP depiction for ODOT intersection layouts

Partner for vehicle on-board units. Connected Vehicle DSRC is a two-way communications that requires vehicles that are outfitted with a DSRC radio integrated with GPS and the Controller Area Network (CAN)[57] bus or an After-market Safety Device (ASD) On Board Unit (OBU). Currently, vehicles are not rolling off the assembly line with the OBU's needed to communicate with agency installed RSE's. Therefore, the Agency must leverage agency fleets, recruit participants, and/or collaborate with the private sector to either outfit vehicles with OBU's or disseminate Agency traveler information via a private sector application.

Ensure use of validated CV equipment. Starting in 2017, Ann Arbor Connected Vehicle Test Environment (AACVTE) will be used to validate and certify CV equipment built to new standards. A four-layer certification program (still under development) will assess the device's environmental abilities (e.g., temperature, vibration, weather); communication protocol abilities (e.g., interoperability for DSRC); interface abilities (i.e., formatting of message syntax and content); and overall application abilities (i.e., system-level functionality).

Design for interoperability. To the extent possible, ensure consistent functionality of deployed applications across transportation modes and regions and compliance with existing federal guidance on ITS and CV practices.

The most critical area of interoperability is in connected vehicle security and privacy. Core to the federal CV security policy is the use of security certificates to ensure secure communication. Security and other information exchange requirements are defined in the USDOT Connected Vehicle standards program. Two critical standards include SAE J2735, which establishes the current accepted message set for a CV environment, and SCMS 2.0 which defines the security credentialing management process. The SCMS certification process is currently being transitioned to CAMP. Therefore, there is currently some uncertainty about who will issue and maintain the certificate credentialing program. The diagram below in Figure 39 highlights the latest understanding of the core information flows between CV systems and the relevant standards that apply.

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[57] CAN bus is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications

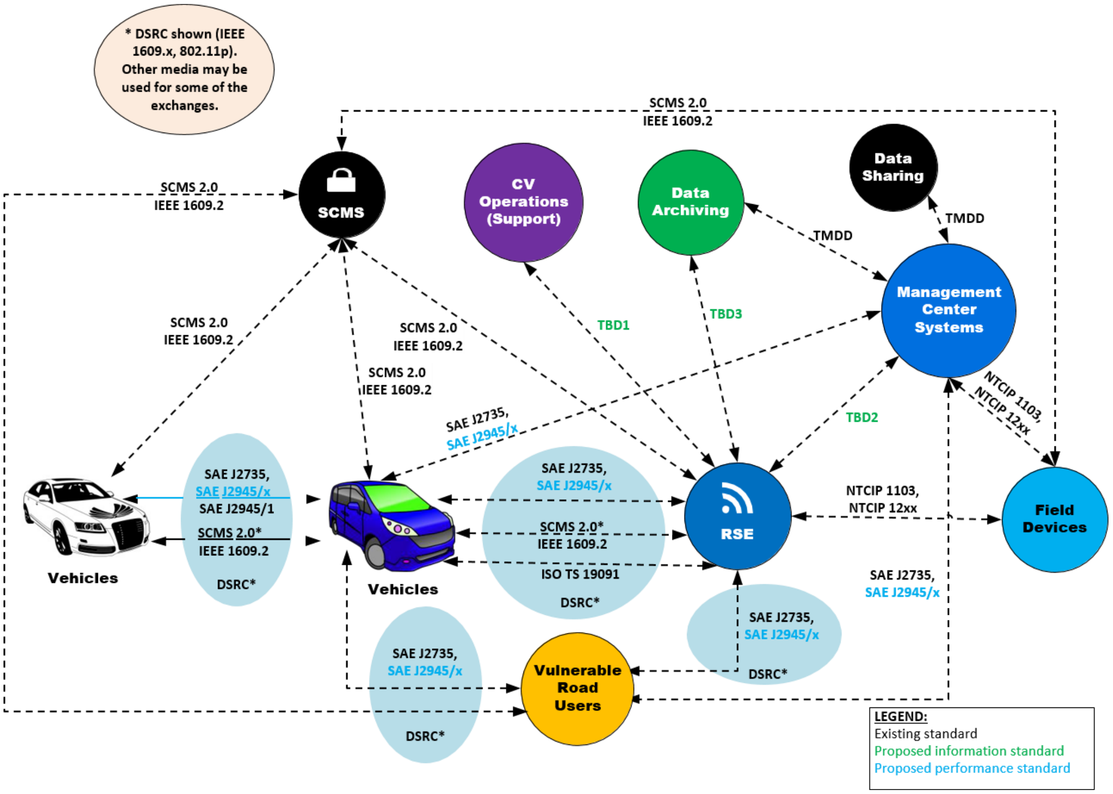

Figure 39. Connected Vehicle Standards Context Drawing.

Source: AASHTO/ITS America/ITE V2I Deployment Coalition STSMO Annual Meeting Presentation, August 2, 2016

Communications Technology

Adopt latest security protocols. Security Credential Management System (SCMS) is the USDOT-developed framework to ensure that messages are secure and coming from an authorized device. The SCMS prototype currently used by the pilot deployment sites is set to be decommissioned by the end of 2016 and replaced with the system developed by the automotive manufacturer partnership, Crash Avoidance Metrics Partnership (CAMP). ODOT should monitor the transition of the security management platform to the CAMP system and ensure that all roadside units and onboard equipment are installed with the latest CAMP SCMS.

Follow systems engineering analysis when selecting V2I communications technology. When evaluating non-DSRC based communication technology, consider these factors: national interoperability, certified application support, and the technology’s ability to meet the needs of the application.

Adopt IPv6 for CV network equipment. As discussed previously in this document, Internet Protocol Version 6 (IPv6) will be a requirement for deploying CV applications given its support for almost unlimited number of IP addresses and quality of service (QoS) capabilities. Some current pilot deployments have attempted to use a hybrid IPv4 / IPv6 network but have found that it increased the network management complexity. In preparation for this migration to IPv6, as ODOT procures new and replacement network equipment, it should identify equipment models that currently support or have firmware upgrades available to enable IPv6. Current RuggedCom/Siemens field network equipment utilized by ODOT, for example, will require minimal modification. ROS1 products (RS900, RS930L, etc.) will be capable of supporting IPv6 with a firmware update expected in early 2017. The ROS2 products (RX1500, RX1400) and Cisco equipment used by ODOT are already compliant with IPv6.

Operations and Maintenance Considerations

Plan for higher initial investment and O&M costs. The CV industry is still maturing and economies of scale are yet to be realized. Recent USDOT Pilot Deployment experience with the current version of the DSRC roadside unit specification (V3) has indicated that the RSU is relatively unstable, requiring frequent maintenance, spot testing, and updates. Under the direction of CAMP, an updated specification (V4.1) is being developed to address the V3 issues and should be available in early 2017. ODOT should note the issues related to the current RSU spec and be cautioned about deploying RSUs running V3.

Monitor emerging commercial O&M tools. Current commercial product offerings for health monitoring of V2I DSRC communications are limited and often cannot provide confirmation about whether a radio is properly broadcasting. USDOT Pilot Deployment participants reported needing to validate broadcasts using separate over-the-air testing. In the future, health monitoring capability will likely be integrated into commercial ATMS systems. However, any near-term ODOT CV deployment should include an over-the-air testing component for validation of message broadcast.

Current and Pending Federal Resources

The following list identifies and provides the status of the major federal Connected Vehicle guidance documents and resources that ODOT should reference as it designs, develops, implements, and operates its CV applications.

Available now:

- Connected Vehicle Planning Processes and Products[58]
- Guide to Licensing DSRC[59]

Pending:

- V2I Deployment Guidance (anticipated in early 2017 once V2V rulemaking complete)
- V2I Message Lexicon (to accompany V2I Deployment Guidance)
- Connected Vehicle Training Resources (anticipated 2017)
- Pre-Deployment Guidance for V2I Safety Applications (anticipated in 2017/2018)
- Model Approach to Advanced Technologies Procurement Using Agile System Engineering (anticipated in 2017/2018)
- Estimating Benefits and Economic Impacts of V2I Deployments (to be made available once CV Pilot Deployments concluded)

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[58] http://www.its.dot.gov/research_areas/cv_planners.htm

[59] http://ntl.bts.gov/lib/56000/56900/56950/FHWA-JPO-16-267.pdf

ITS STANDARDS

ITS standards, developed through industry consensus, define how system components should work within the National ITS Architecture to support deployment of interoperable systems at local, regional, state, and national levels. The U.S. Department of Transportation (U.S. DOT) ITS Standards Program has developed cooperative agreements with standards development organizations (SDOs) for development of non-proprietary, industry-based standards (approximately 100 separate standards are in various phases of development) and has been encouraging the use of standards for ITS interoperability. They maintain a website[60] that provides ITS standard development status and activities as well as deployment resources (technical assistance, training, publications, standards testing, and forums).

This section includes a summary of why standards should be used, the standards development and adoption processes, interface classes and standards application areas, and a description of how standards are applied to the Oregon Statewide ITS Architecture.

Why Use ITS Standards?

ITS standards should be used for the following reasons[60]:

- ITS standards are open and non-proprietary, helping state and local transportation managers avoid costly single-source procurements and locked-in maintenance relationships with vendors.
- ITS standards support the deployment of interoperable ITS systems, helping agencies link together different types of ITS technologies and making system expansions easier to plan and implement.
- ITS standards are being developed for many different types of ITS technologies and their use is being supported by the U.S. DOT through technical assistance programs, training, and deployment outreach and guidance.
- Using ITS standards in project development is a key aspect of conformity with the FHWA Rule/FTA Policy on ITS Architecture and Standards.

ITS Standards Development and Adoption Processes

The SDOs are developing standards that can be used across many different types of transportation applications. It is important to understand that it takes time to develop, approve, and publish a standard and that it takes even more time for manufacturers to incorporate these standards and place them on the market. It is important to note that ITS standards are typically functional standards that give transportation agencies confidence that components from different manufacturers will work together (e.g. the equipment will talk a common language), without removing the incentive for designers and manufacturers to compete to provide products that are more efficient or offer other features. However, there are also a limited number of ITS standards that provide specific equipment standards to ensure device compatibility between manufacturers. An ITS standard undergoes two separate processes: a development process and an adoption process.

The standards development process is led by the SDOs, which are professional industry associations such as the Institute of Transportation Engineers (ITE) and National Electrical Manufacturers Association (NEMA), and may be developed by a single SDO or jointly by

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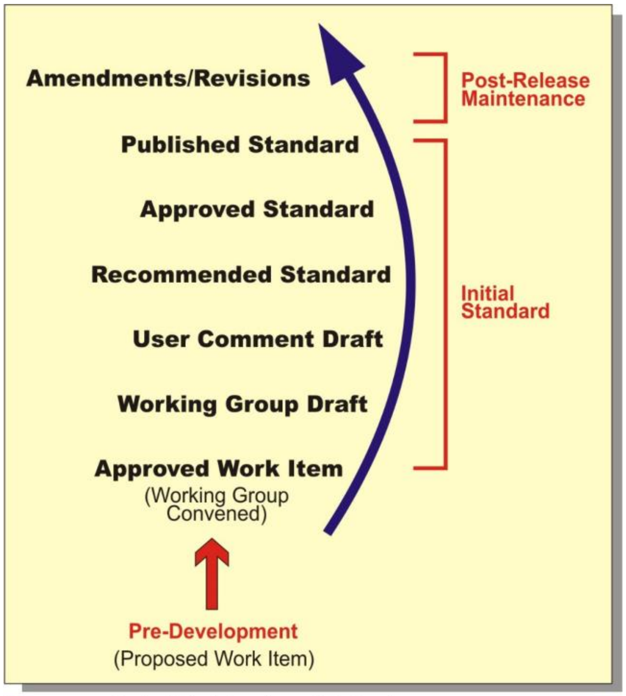
[60] *ITS Standards Program*. U.S. Department of Transportation. May 2006. http://www.standards.its.dot.gov/default.asp. Accessed May 9, 2006.

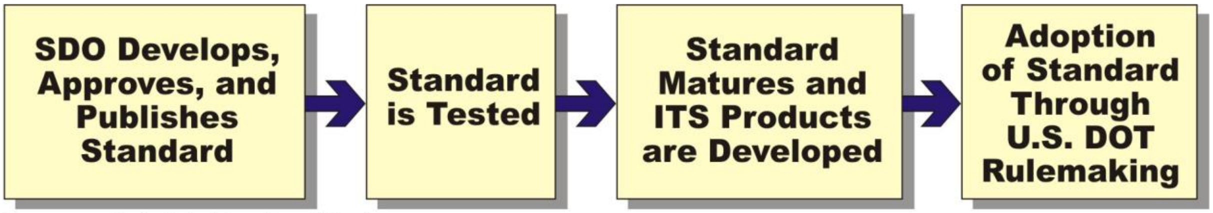


Source: www.standards.its.dot.gov/learn_StdsDevel.asp

Figure 40. ITS Standards Development Process

several SDOs. Figure 40 illustrates the ITS standards development process. Each standard is first developed by a working group, which consists of professionals with expertise about an ITS component to which the standard is expected to apply, and is then subjected to thorough review. Once review comments have been incorporated the standard is put to ballot for SDO voting. If approved, the standard is then published by the SDO. Appendix O includes a full list of ITS standards and their 2010 development status. Currently 88 standards are published, four are approved, two are in ballot, and four are under development.

Once a standard is published it goes through an adoption process as depicted in Figure 41. A standard must be tested under realistic transportation operating conditions to measure the correctness and completeness of the standard. A standard gradually matures through testing and revisions and attracts vendor competition to develop products with features exceeding the minimum functional requirements. Finally, a mature standard may be considered for adoption by the U.S. DOT if it meets established criteria. Adopted standards must then be used on any project funded from federal sources. Although the U.S. DOT has yet to adopt any ITS standards there are a number of standards that are slowly maturing through testing and product development.



Source: www.standards.its.dot.gov/learn_Lifecycle.asp

Figure 41. Life Cycle of an ITS Standard

Interface Classes and Standards Application Areas

Interface classes and standards application areas help determine which standards may be applicable to a project. The interface classes define the subsystem class (center, field, vehicle, or traveler) at each end of the communications path. Standards application areas, which are deployment-oriented categories, focus on common ITS deployments within each interface class. Table 25 lists the relationship between the interface classes and standards application areas. More applications will be added to this table on a national level as additional ITS standards become available.

Table 25. Standards Application Areas by Interface Class (2010)

Interface Classes	Standards Application Areas	
Center-to-Center (C2C)	▪ Data Archival ▪ Incident Management ▪ Rail Coordination	▪ Traffic Management ▪ Transit Management ▪ Traveler Information
Center-to-Field (C2F)	▪ Data Collection/Monitoring ▪ Dynamic Message Signs ▪ Environmental Monitoring ▪ Ramp Metering	▪ Traffic Signals ▪ Vehicle Sensors ▪ Video Surveillance
Center-to-Vehicle/Traveler	▪ Mayday ▪ Transit Vehicle Communications	▪ Traveler Information
Field-to-Field	▪ Highway Rail Intersection	
Field-to-Vehicle	▪ Signal Priority	▪ Toll/Fee Collection

The National Transportation Communications for ITS Protocol (NTCIP) is the most applicable for transportation agencies because it defines C2C and C2F communications standards. The NTCIP defines a common set of rules for communicating (called protocols) and the vocabulary (called objects and definitions) to allow electronic devices (at centers and in the field) made by different manufacturers to operate with one another as a common system. The three primary types of NTCIP standard types are similar to the human language as described in Table 26.

Table 26. Standard Types and Relationship to Human Communications

Computer Language	Human Communications
Object definitions/data elements	Vocabulary of words
Message sets	Sentences with grammar rules
Communication protocols	Describes how the data is exchanged (similar to the rules used to address a letter)

ITS Standards in Oregon

Although standards development is broad and many standards have yet to reach maturity there are a number of ITS standards that either are currently in use or may be considered for use based on the architecture flows selected in the Oregon Statewide ITS Architecture. Out of all the stakeholders ODOT has spent the most time analyzing, approving, and utilizing ITS standards for use around the state. The following practices highlight ODOT’s 2010 experience with the adoption of ITS standards:

- Common Standards: ODOT is currently using most of the approved message set and data definition standards when available and applicable, particularly: *ITE TM 1.03: Standard for Functional Level Traffic Management Data Dictionary (TMDD)* and *ITE TM 2.01: Message Sets for External TMC Communications (MS/ETMCC)*.

- Center-to-Center Standards: ODOT currently uses XML[61] for center-to-center communication, as opposed to DATEX[62].
- Center-to-Field Standards: Most NTCIP standards for field devices are still in development. ODOT is currently utilizing *NTCIP 1203: Object Definitions for Dynamic Message Signs* and *NTCIP 1204: Environmental Sensor Station (ESS) Interface Standard* and will continue to review all other relevant NTCIP standards when deploying new field devices.

Appendix P includes the 2010 Turbo Architecture report of the ITS standards that have been selected for the Oregon Statewide ITS Architecture. ODOT typically reviews ITS standards on a project-by-project basis as part of the systems engineering process. Once the detailed project requirements have been identified ODOT determines the applicability of available ITS standards. The architecture should be updated as additional ITS standards are selected for use or ruled out.

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[61] eXtensible Markup Language (XML): a universal structured data transfer methodology that is currently widely used in e-business and e-government applications.

[62] DATa EXchange Between Systems (DATEX): a fixed message-based protocol that defines how the information is formatted and sent over a wire.

PROJECT SEQUENCING

The sequencing of ITS projects provides a framework for implementing integrated statewide systems that support the Oregon Statewide ITS Architecture. Since infrastructure and communications networks are often shared between ITS projects it is important to implement projects in an efficient, incremental sequence that takes into account dependencies on other projects. This section includes a summary of the desired sequencing of ITS projects in Oregon over the next five years as well as a project sequencing matrix.

Staffing and funding play a key role in the rate at which projects may be deployed. Whether projects are developed and/or designed in house or contracted out, the ODOT ITS Unit and other ODOT departments (e.g. district maintenance offices) must have adequate staffing to manage each project and to support the ongoing maintenance and operations required upon project completion.

Funding must also be secured to support project development, construction, maintenance, and operations. Funding for statewide ITS projects is determined by the Oregon *Statewide Transportation Improvement Program* (*STIP*), which allocates federal and state funding for state and regional transportation systems over a four-year period. The *STIP* is updated every two years and is adopted by the Oregon Transportation Commission and then submitted to the Federal Highway Administration and Federal Transit Administration per federal law. Within the *STIP*, the Operations Program provides ITS funds since ITS projects typically support transportation system efficiency. Instead of assigning funding to specific ITS projects the *STIP* typically includes four general ITS funding allocations for each year of the *STIP*. This allows greater flexibility for allocating funds to projects, especially since schedules often change and ITS project budgets vary in size. The funding was approximately $1.2 million per year in the last *STIP*.

The ODOT ITS Unit plans project implementation on a biennium basis using the funding from the *STIP*. To match this process the ITS projects in this plan have been sequenced into three categories: the 2015 – 2017 Biennium, the 2017 – 2019 Biennium, and the 2019 – 2021 Biennium as shown in Table 27. Projects were assigned to each biennium based on input from the Statewide Architecture Committee, current staffing levels, available *STIP* funding, relativity to other planned projects, project dependencies, technical and institutional feasibility, and equitable distribution of projects. All of the projects support the statewide ITS vision and goals described in the Operational Concept section. Project sequencing should be reevaluated prior to each biennium to determine if changes are needed based on staffing levels, funding allocation, schedule adherence, shifts in statewide priorities, changes in national ITS initiatives, and technical feasibility.

Table 27. ITS Project Sequencing Matrix for Years 2015 – 2021

Project Name	Project Description	Service Area								
		TOCs	Regional Traffic Control	Traveler Information	Maintenance / Construction Ops	Connected Vehicle	Road Weather Ops	Incident Mgmt	Archived Data Mgmt	Public Transportation
2015 – 2017 Biennium Projects										
TOCS Resource Management	Redesign TOCS unit management functions to allow for easier unit assignment and workflow control of resources through event life cycle. Also add basic screen layout customization allowing dispatchers to have some flexibility in managing their own views.	X					X	X		
TOCS Maintenance Releases	Quarterly maintenance updates that address existing bugs and minor enhancements to existing TOCS functions.	X					X	X		
TOCS Response Plan Management	Add a response plan tool to the TOCS system that selects and helps implement the appropriate pre-planned response based on an event location and attributes. Develop event response plans for major state routes including alternate travel routes, field device locations and clearly defined Agency roles and responsibilities when multiple Agencies are involved.	X		X			X	X		
TOCS Archive Phase 2	Implement an ongoing daily archival process that moves TOCS data to an archive / data warehouse database.	X							X	
TOCS Event File Management	Allow TOCS users, including incident responders and INVIEW stakeholders to attach files such as photos to TOCS Events.	X			X		X	X		
TOCS Infrastructure 2012 Upgrade	Implementation of TOCS application and database servers to 2012 servers. Includes upgrade of HTCIS database.	X								
TOCS Maintenance Releases	Quarterly maintenance updates that address existing bugs and minor enhancements to existing TOCS functions.	X								
ITS Server Replacement	Yearly replacement of ITS servers that have reached the end of their 5-year life.	X	X	X		X	X	X	X	
INVIEW Map Replacement	Replace the existing INVIEW map architecture based on the Silverlight technology to use the .Net architecture used by TripCheck.	X					X	X		
Video Distribution	Transition current analog video processing servers and hardware to the digital video distribution system statewide.	X	X	X			X	X		
TOCS Line Event Enhancement	Enhance TOCS to allow dispatchers to enter events that can show in TripCheck as a line segment along a state route, such as a highway closure.	X		X			X	X		
TOCS Event File Management	Add the ability to associate files such as photos to TOC events.	X								
ATM Failover Architecture	Enhance the current production ATM system to include a redundant application and database server.		X				X			
ATM 2016 Maintenance Update	Provide enhancements to the ATM system that accommodates new VMS message capabilities and automated notification for congestion thresholds.		X	X						
TripCheck NOAA Map	Replace the NOAA static map with the new TripCheck map and hot zones for each NOAA area that display current NOAA conditions and forecast information.			X						
TripCheck Travel Time	Enhance the TripCheck map data to include travel time information that is currently provided to travelers on Variable Message Signs.			X						
TripCheck Waze	Integrate Waze-user reported incident data into TripCheck.			X						
TripCheck Server Upgrade	Upgrade TripCheck servers to more current Server OS and SQL database version.			X						
TripCheck ASP Upgrade	Upgrade TripCheck from classic ASP to ASP.Net and implement new functionality and architecture for text reports.			X						
TripCheck Speedmap Upgrade	Update the main TripCheck map to incorporate Portland speed information that has been provided using a separate map.			X						
Connected Vehicles Analysis	Conduct an initiative assessment to identify the first connected vehicle pilot project for ODOT.					X	X			
Performance Measurement Analysis	Conduct an assessment to identify new ITS program metrics and performance measures.	X	X	X	X		X	X		

Project Name	Project Description	Service Area								
		TOCs	Regional Traffic Control	Traveler Information	Maintenance / Construction Ops	Connected Vehicle	Road Weather Ops	Incident Mgmt	Archived Data Mgmt	Public Transportation
TTIP/TLE – Analysis	Analysis to determine new data needs as well as formatting requirements to meet current and projected TTIP stakeholder needs.					X				
Statewide Central Traffic Signal Implementation	Procure and implement a statewide centralized traffic signal system and migrate existing regional instances to the new system.			X						
Oregon State Police Variable Speed Limit Website	Develop a web application UI that is accessible by ODOT and OSP staff to obtain/view/save locally the current speed limit and historical speed limit data.		X				X			
Variable Speed Limit Notification	Using the TOCS/INVIEW notification functionality, allow users to subscribe to receive notifications when the variable speed limit changes for a specific highway segment.		X				X			
Camera Services Replacement	Upgrade the utility used to manage the inventory of cameras displayed on TripCheck and the still image capture configurations.	X	X	X	X		X	X		
2017 – 2019 Biennium Projects										
TOCS Maintenance Releases	Quarterly maintenance updates that address existing bugs and minor enhancements to existing TOCS functions.	X								
ITS Server Replacement	Yearly replacement of ITS servers that have reached the end of their 5-year life.	X	X	X	X	X	X			
GIS Infrastructure Upgrade	Work to retire current ITS GIS servers and use new GIS unit 10.2 infrastructure.			X						
PDCC Bus Integration	Expand inter-agency messaging communications with Portland's Dispatch Consortium, consisting of the City of Portland, Tri-County Agencies, and WSDOT.							X		
Connected Vehicles Pilot 1	Implement the first Connected Vehicle Pilot for Oregon.					X				
SCAN Replacement	Replace the existing SCAN system.			X			X			
Performance Measurement Capture & Reporting	Design and implement new ITS performance metrics and reports.	X	X	X	X		X	X		
Windows 10 Remediation	Test all ITS systems with the Windows 10 OS and browser and remediate applications as needed.	X	X	X	X		X	X	X	
TTIP Bridge Lift Data	Collect and disseminate Portland bridge lifts through the TripCheck Transportation Information Portal (TTIP).		X	X						
TOCS Response Plan – Auto "Call-out"	Implement a system that will automate the procedure in which dispatchers manually call units to get someone to respond to an event.	X								
Variable Speed Enforcement Integration	Working with OSP, develop solution to notify OSP troopers when a Variable Speed Limit is active and when it is no longer active.			X						
TripCheck Mobile App	Develop a mobile application that a user downloads from an app store.			X						
INVIEW Map Replacement Phase 2	Implementation of new features like controlling a camera via the Map interface and adding more location data attributes (example - click on map and get who the public utility companies are.)	X								
Expand OSI Partners	Connect Klamath, Crook, and Lake County to the Oregon Interoperability Server.							X		
TOCS ForseCom Integration	Integrate TOCS with Forsecom to eliminate the current inefficiency of having to use two different applications.	X						X		
INVIEW Cross-Browser Compatibility	Improve INVIEW to work on multiple browsers (currently only developed to work for IE).	X						X		
Mobile Device Access to TOCS Events	Implement solution that allows an incident responder, using a phone, to be able to be authenticated (2 factor) and take a picture that can be associated with and saved to a TOC event.	X						X		
ATM Expansion	Expand ATM to other corridors in the state.		X				X			
Public Service Announcement Integration with MQM	Implement a solution that allows a custom message to be created using a WYSIWYG interface and publish the message to the MQM.	X		X						
TTIP Modernization - Implementation	Implementation of the requirements defined during the TTIP/TLE analysis phase.			X		X	X			

Project Name	Project Description	Service Area								
		TOCs	Regional Traffic Control	Traveler Information	Maintenance / Construction Ops	Connected Vehicle	Road Weather Ops	Incident Mgmt	Archived Data Mgmt	Public Transportation
TLE Modernization - Implementation	Implementation of the requirements defined during the TTIP/TLE analysis phase.			X		X	X			
TOCS Role-based Permissions	Re-evaluate and refactor role-based permissions at the sub-function level within the TOCS admin tool and underlying TOCS code.	X								
INVIEW Serious/Fatal/Hazardous Material Reporting	Enhance INVIEW to allow a Transportation Maintenance Manager the ability to fill out a report. Some of the data in the report will be auto populated from the TOCS event.	X								
Traffic Signal Data Consolidation - Analysis	Analyze all the databases in which Traffic Signal information is stored. Interview Traffic Signal data stakeholders and document their needs/requirements. Examples of where Traffic Signal info is store include MicroMain and TSIS. ODOT Traffic section is also looking at gathering and storing Traffic Signal intersection asset information and ADA info. Define solution options to consolidate data into one master data source (if feasible.)		X							
2019 – 2021 Biennium Projects										
TOCS Maintenance Releases	Quarterly maintenance updates that address existing bugs and minor enhancements to existing TOCS functions.	X								
ITS Server Replacement	Yearly replacement of ITS servers that have reached the end of their 5-year life.	X	X	X	X		X	X		
TripCheck Local Entry Upgrade	Upgrade of the TLE Map (Bing) to use the TripCheck Map architecture.			X						
TOCS / Micromain Report Enhancements	Implement enhancements to TOCS that integrates data from Micromain.	X			X		X			
TOCS Traffic Management	Enhance TOCS to allow for response plans that would give TOC operators the ability to adjust an arterial signal timing plan based on an event such as a major detour.	X	X	X			X	X		
TOCS HAR Integration	Implement a HAR response plan based on a TOCS event.	X		X				X		
TOCS WebEOC Integration	Provide TOC data to the WebEOC system that allows managers to receive near real-time information for incidents in a selected corridor.	X	X	X	X		X	X		
TOCS City of Portland Tow Desk Integration	Integrate a data exchange between TOCS and the City of Portland.	X	X							
InfoCaster Replacement	Replace the current Infocaster system with a more robust system.			X						
General Transit Data	Concept - provide more robust transit data and functionality (TripCheck).									X
TripCheck Traveler Customization	Implement functionality to allow an end user to customize an information portal. E.g. A commuter may want a predefined view of information for their morning commute.			X						
TripCheck Bike Path	Improve bicycle information on TripCheck.			X						
TripCheck Mountain Passes	Implement enhancements to TripCheck that provide weather conditions, highway images, incidents and other traveler information for select corridors / mountains similar to WSDOT's.			X						
TripCheck Web Streaming	Implement web streaming from ODOT cameras on TripCheck.			X						
TripCheck Travel Time Forecasting	Implement functionality that forecast out what conditions may be like in the future.			X						
AVL Snow Plow tool w/ INVIEW & TOCS Integration	Provide snow plow information in near real time on the INVIEW Map.	X					X			
Waze Integration with TOCS	Use Waze data to create TOC events under certain conditions.	X								
TOCS Resource Management Phase 2	Enhance unit assignment screens in TOCS to allow dispatchers more robust customization options for screen placement and content.	X								
Incident Response Checklist	Enhance TOCS to assist dispatchers in managing incidents to include automated checklists based on the incident type and location.	X								
Connected Vehicles Pilot 2	Implement the second Connected Vehicle Pilot for Oregon.					X				

Project Name	Project Description	Service Area								
		TOCs	Regional Traffic Control	Traveler Information	Maintenance / Construction Ops	Connected Vehicle	Road Weather Ops	Incident Mgmt	Archived Data Mgmt	Public Transportation
Traffic Signal Data Consolidation - Implementation	Implement the suggested solution determined as part of the analysis project.		X							
Statewide Congestion Map	Enhance the TripCheck map to display congestion information statewide.			X			X			

MAINTENANCE PLAN

The Statewide Architecture Committee used federal guidelines[63] to develop a maintenance plan for keeping the Oregon Statewide ITS Architecture up to date. The development and implementation of an architecture maintenance plan is one of the requirements of the FHWA Final Rule and FTA Policy. The architecture is a fluid entity that must be updated as ITS needs and services evolve in Oregon. This section answers the following questions: Who? What? When? How?

Who Maintains the Oregon Statewide ITS Architecture?

In general the ODOT ITS Unit is responsible for maintaining the Oregon Statewide ITS Architecture and have been the keeper of it since it was first developed. The ODOT ITS Unit is well versed in the contents of the architecture and is proficient in Turbo Architecture. One staff member within the ODOT ITS Unit will be responsible for performing the actual maintenance to the Oregon Statewide ITS Architecture[64]. This staff member will be referred to as the Maintainer throughout the rest of this section. The rest of the ODOT ITS Unit will be responsible for reviewing and approving all updates.

What is Maintained in the Oregon Statewide ITS Architecture?

The following items in the Oregon Statewide ITS Architecture will be maintained to reflect the deployment of ITS projects and changes in statewide needs:

- Statewide architecture attributes
- Project architectures and attributes
- Stakeholders
- Inventory elements
- User services/market packages
- Operational concept
- Interconnects and information flows between elements
- ITS standards
- Project sequencing

Deletions or additions to the Oregon Statewide ITS Architecture should be accompanied with descriptive comments in Turbo Architecture to document the reasons for the changes.

When is the Oregon Statewide ITS Architecture Updated?

Approaches to architecture maintenance include periodic, exception based, or a combination of the two methods. The Committee has decided that a combination of the two methods is the best approach for the Oregon Statewide ITS Architecture as follows:

- Exception Based Architecture Maintenance: The architecture will be updated when a statewide project impacts a large portion of the architecture.
- Periodic Maintenance: Planned maintenance of the architecture will occur every two years in odd-numbered years closely following the biennium financial planning for ITS projects.

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[63] *Regional ITS Architecture Maintenance White Paper*. Report FHWA-HOP-04-004. U.S. Department of Transportation, Federal Highway Administration, National ITS Architecture Team, Jan. 31, 2004.

[64] At the present time Patrick Hoke is the ODOT ITS Unit staff member responsible for architecture maintenance.

How is the Oregon Statewide ITS Architecture Maintained?

The Maintainer will be responsible for updating the Oregon Statewide ITS Architecture based on things such as changes to existing ITS elements or operations, addition of new projects, or status changes when funding is secured. Table 28 lists the general process for maintaining the architecture for both exception based and periodic maintenance updates.

Table 28. Oregon Statewide ITS Architecture Update Process

Maintenance Step	Responsibility
Exception Based Maintenance	
Work with project engineer to update the applicable portions of the Turbo Architecture database based on a project.	Maintainer*
Log the changes and notify the ODOT ITS Unit.	
Approve the changes to the Turbo Architecture database and supporting documentation. This may be done during a meeting or by e-mail.	ODOT ITS Unit
Periodic Maintenance	
Update the entire architecture every two years to reflect statewide changes.	Maintainer*
Log the changes and notify the ODOT ITS Unit.	
Hold a meeting to review the changes.	ODOT ITS Unit
Approve the changes to the Turbo Architecture database and supporting documentation.	
* The Maintainer is a staff member from the ODOT ITS Unit who is proficient in Turbo Architecture.	

The Maintainer should use caution when building new flows in Turbo Architecture, which must be done when additional inventory elements are added or the subsystems and terminators for existing inventory elements are modified. Tailoring new flows within Turbo Architecture is easiest if the "conservative" setting is selected prior to running the build command.

FUTURE CONSIDERATIONS

The following topics, which came up during the course of this project and were unable to be addressed at this time, should be revisited during future maintenance of the Oregon Statewide ITS Architecture:

- **Custom Architecture Flows:** Turbo Architecture currently allows users to create custom architecture flows but does not allow these flows to be assigned to any market packages. Iteris, who manufactures the software, is aware of this issue and is planning to add this capability to Turbo Architecture as part of their next software upgrade. Once that capability is available the custom flows currently in the Oregon Statewide ITS Architecture that interface with LEDS (“vehicle information request” and “vehicle information”) should be added to the ATMS08 (Traffic Incident Management System) market package.

- **Mayday Integration:** If the Oregon Interoperability Service ends up being used to relay messages from mayday service centers to ODOT the EM03 (Mayday and Alarms Support) market package and associated flows will need to be updated.

- **Vehicle Probes:** ODOT had a project underway to collect data from Bluetooth devices to determine travel times on Portland area travel routes. The 2010 architecture was updated based on the assumption that the data will be collected by commercial ISPs and then sent to ODOT through TTIP. These interfaces should be revisited during the next architecture update to make sure the architecture accurately reflects this process.

- **National ITS Initiatives:** Update the architecture as major national ITS initiatives mature and become ready for use in Oregon, particularly as emerging technologies advance within the connected and automated vehicle service area.

- **Road User Charging:** Specific stakeholders and their associated roles and responsibilities will need to be added to this plan when road user charging applications are implemented.

- **National ITS and Turbo Architecture Updates:** Update the statewide ITS architecture to reflect changes to the National ITS Architecture and Turbo Architecture since Version 6.1. Versions 7.0 and 7.1 have been released since then. Major updates to Turbo Architecture are anticipated in 2017.