Final Report
S2-25869

Thurston Smart Corridors System Engineering Reference Manual

Submitted to Thurston Regional Planning Council

by IBI Group

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System Engineering Reference Manual

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Background and Overview

1. Introduction

Thurston Smart Corridors is a technology-based initiative to improve multimodal transportation operations in key arterial corridors in urbanized Thurston County. Goals of the program include a reduction in stop-and-go traffic and increase transit operating efficiency.

Thurston Smart Corridors is funded through a Congestion Mitigation and Air Quality (CMAQ) grant administered by Thurston Regional Planning Council. The objective of the CMAQ funding is to implement high priority transportation projects that provide cost-effective benefit to particulate matter emissions, specifically PM10, in the urbanized area of the County.

Thurston Smart Corridors is one of the region's first and most extensive multi-agency, multi-modal initiatives in Transportation System Management and Operations (TSMO). Accordingly, significant effort has been invested in a regional conversation about the operational needs, opportunities, constraints, and long-range vision for Smart Corridors. As a demonstration project, Thurston Smart Corridors lays the groundwork for other collaborative operational strategies in the future.

Thurston Smart Corridors reflects a regional movement towards transportation strategies that are relatively low cost and address operational causes of transportation system congestion, inefficiency, and unreliability. Similar operational strategies, including traffic signal system coordination and transit signal priority, have been employed successfully in urban areas across Washington State and around the country.

1.1. Regional Transportation Operations Working Group (RTOG)

The Thurston Regional Planning Council (TRPC) is facilitating a working group of regional operations staff known as the Regional Traffic Operations Group (RTOG) responsible for development, implementation, and ultimately ongoing operation of the Smart Corridors concept.

The RTOG is a coordinated regional effort to address existing and emerging mobility challenges related to inter-jurisdictional and intermodal traffic operations in the Olympia region.

The participating RTOG agencies are shown in *Exhibit A-1* .

Exhibit A-1: Participating RTOG Agencies

Descriptions of participating RTOG agencies are provided in the table below.

AGENCY	DESCRIPTION
City of Olympia	Owns and operates traffic signal infrastructure within the City of Olympia's municipal boundaries as well WSDOT signals on Pacific Avenue. Also provides police, fire, and EMS services including freeway incident response.
City of Tumwater	Owns and operates traffic signal infrastructure within the City of Tumwater's municipal boundaries. Also provides police, fire, and EMS services including freeway incident response.
City of Lacey	Owns and operates traffic signal infrastructure within the City of Lacey's municipal boundaries as well as certain signals within unincorporated Thurston County. Also provides police, fire, and EMS services including freeway incident response.
Thurston County	Owns traffic signals in unincorporated sections of the Smart Corridors, operated under contract by the City of Lacey.
Washington State Department of Transportation (WSDOT) - Olympic Region	Owns and operates traffic signals (including freeway ramp signals) as well as other ITS infrastructure in the region. The Olympic Region Traffic Management Center (TMC) in Pierce County is responsible for traffic management in Thurston County.
Intercity Transit	Operates fixed-route and demand responsive public transportation in Thurston County as well as express routes into Thurston County. The Smart Corridors are operationally critical for the agency with the system's highest levels of service and ridership.
Federal Highway Administration (FHWA)	Responsible for oversight of federal transportation policies and administration of federal transportation funding, including Intelligent Transportation Systems integration and interoperability.
Thurston Regional Planning Council (TRPC)	Regional planning agency for Thurston County which facilitates the RTOG group as part of its mission to improve mobility and regional cooperation to address the region's transportation needs.

Exhibit A-2: Description of Participating RTOG Agencies

2. Smart Corridor Descriptions

2.1. Martin Way / 4th Avenue / State Avenue

Martin Way is a major commuter and commercial corridor connecting Lacey to Downtown Olympia. The Martin Way Smart Corridor extends roughly 6.5 miles from Capitol Way in Downtown Olympia east to Marvin Road in Lacey.

The Downtown Olympia portion is split between State Avenue for Westbound traffic and 4th Avenue for eastbound traffic. Roughly half of the route is located within Olympia, with the rest split between Lacey and unincorporated Thurston County.

Martin Way transitions from a regular street grid pattern in Downtown Olympia to a suburban setting with widely-spaced intersections in Lacey. The corridor meets I-5 at a full interchange just east of College Street in Lacey, where an Intercity Transit Park and Ride Facility is also located. Traveling east, the corridor passes into unincorporated Thurston County for a short distance before reentering Lacey just west of Marvin Road.

The Martin Way corridor includes 39 traffic signals. For further details on these intersections, please refer to **Appendix I2** that provides an inventory of traffic signals for the Smart Corridors region, **Tab C**, *Corridor Reference Maps – Traffic Signal Interconnects*, provides a map of these signal locations along the Martin Way / 4th Avenue / State Avenue corridor.

2.2. Capitol Way / Capitol Boulevard

The Capitol Way / Capitol Boulevard Smart Corridor extends roughly 4.6 miles from State Avenue in Downtown Olympia to Tumwater Boulevard in Tumwater and is a significant commuter corridor while also carrying traffic from Olympia Regional Airport and smaller towns to the south, such as Tenino. The northern 40% of the route is located in Olympia while the southern 60% is in Tumwater. The route is named Capitol Way in Downtown Olympia and becomes Capitol Boulevard to the south.

Like the Martin Way corridor, the Capitol Way corridor transitions from an urban grid in downtown Olympia to a more suburban characteristic in Tumwater, with traffic speeds generally higher in the south where intersections are spaced less frequently. Capitol Boulevard crosses over I-5 south of the State Capitol before acting as a frontage road between E Street and Trosper Road.

The corridor includes 19 signalized intersections, 9 of which are owned and operated by the City of Olympia and the rest owned by the City of Tumwater. For further details on these intersections, please refer to the **Appendix I2** that provides an inventory of traffic signals for the Smart Corridors region. **Tab C**, *Corridor Reference Maps – Traffic Signal Interconnects*, provides a map of these signal locations along the Capitol Way / Capitol Boulevard corridor.

“Exhibit A-3: Capitol Way / Capitol Boulevard Corridor Signal Groups Map” and “Exhibit A-4: Martin Way / 4th Avenue Corridor Signal Groups Map” show the extents of the Smart Corridors.

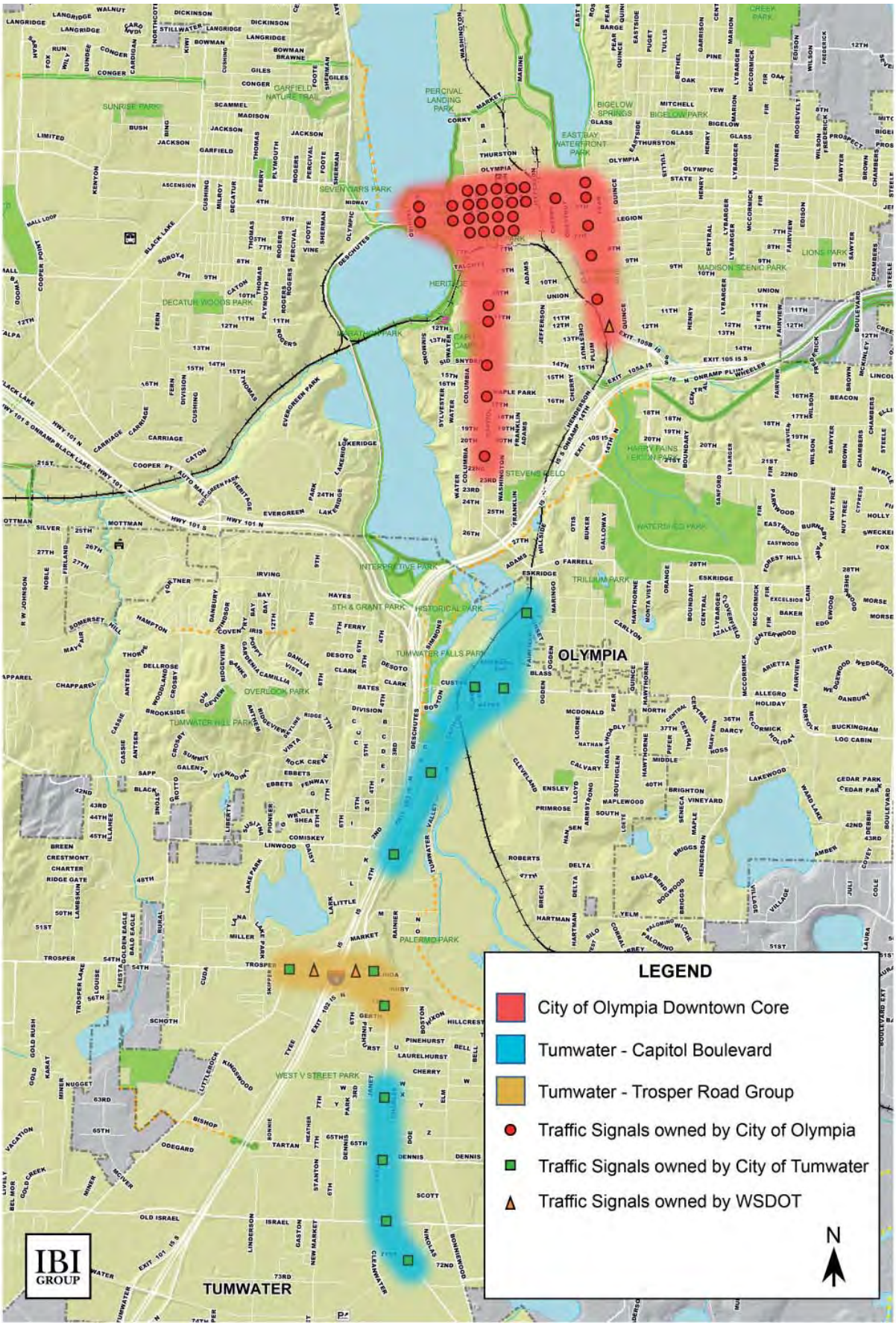

Exhibit A-3: Capitol Way / Capitol Boulevard Corridor Signal Groups Map

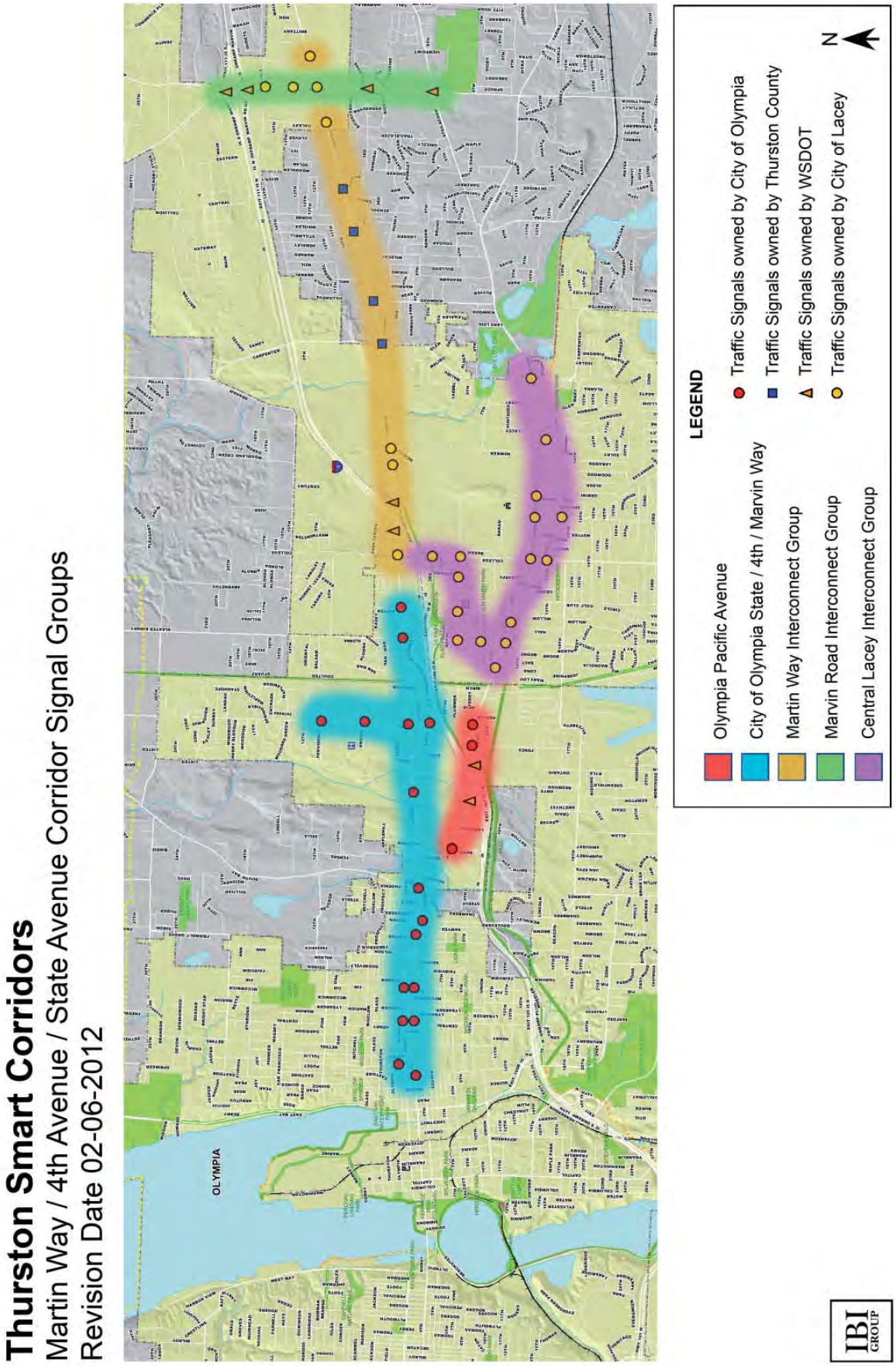

Exhibit A-4: Martin Way / 4th Avenue Corridor Signal Groups Map

2.3. Smart Corridors Operational Objectives

There are four primary categories of Smart Corridors operational objectives that were explored by the stakeholder agencies through the visioning process. These are:

- Arterial Operations
- Transit Operations
- Freeway Operations
- Emergency Management

Not all of the concepts explored by the RTOG were ultimately deemed viable under the Smart Corridors project in the near term. However, the conversation was valuable in clarifying high-level functional requirements for the Smart Corridors project, as well as highlighting the long-term potential of future operational programs and joint Intelligent Transportation Systems (ITS) technology investments in Thurston County.

Specific baseline conditions and needs for each of these operational categories are discussed in detail in **Tab C** of this document. A summary of the key operational objectives is presented in "Exhibit A-6: Issues and Objectives Identified by Partner Agencies".

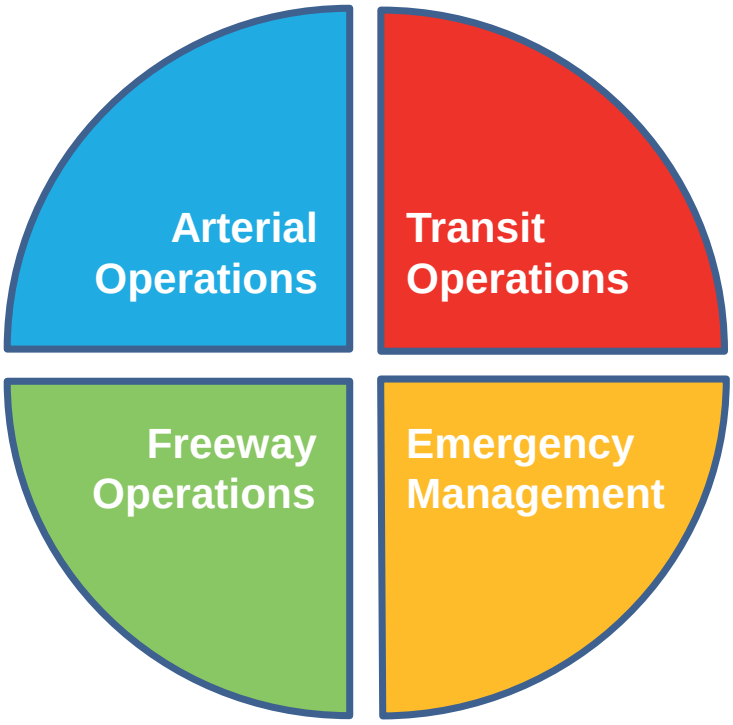

Exhibit A-5: Four Primary Categories of Smart Corridors

OPERATIONAL AREA	ISSUES AND OBJECTIVES IDENTIFIED BY PARTNER AGENCIES
Arterial Operations	• Maximizing traffic throughput and reliability through effective timing and coordination of traffic signals on the Smart Corridors as well as key intersecting arterials • Improving coordination of traffic signals across jurisdictional boundaries to improve end-to-end corridor performance • Replacing traffic signal equipment that has reached the end of useful life, and which has significant functional and / or physical limitations • Increasing traffic signal system responsiveness of traffic to changing traffic conditions based on time of day, day of week, and due to special events • Improving central signal system monitoring, management • Enhancing data and analysis capabilities for performance measurement (including data for regional planning)
Transit Operations	• Increasing the reliability of transit performance (schedule adherence) by mitigating the impacts of traffic congestion and delay along the Smart Corridors • Reducing overall transit run times to increase the competitiveness of transit for customers, and to reduce associated operating costs • Providing an operational testbed for Transit Signal Priority technology as a basis for possible future expansion across the region
Freeway Operations	• Supporting implementation of designated WSDOT freeway detour plans, e.g. by implementing a detour signal timing plan on parallel arterial routes • Leveraging future opportunities to integrated local ITS systems with the WSDOT Traffic Management Center, as freeway ITS equipment and operational presence increases in the I-5 / US 101 corridors in Thurston County
Emergency Management	• Maintaining the integrity of existing Emergency Vehicle Signal Pre-emption systems currently installed and in use in the Smart Corridors • Long-term opportunities to provide incident and traffic information to emergency responders, e.g. through shared traffic information or video surveillance images

Exhibit A-6: Issues and Objectives Identified by Partner Agencies

2.4. Use of the Systems Engineering Process in Smart Corridors Planning

The planning of the Thurston Smart Corridors project followed the Systems Engineering process, as required by FHWA and WSDOT regulations. The Systems Engineering process is a method for developing and implementing complex technology systems to ensure that the meet end user needs and the functional requirements identified by stakeholder agencies. This method also ensures that ongoing operational roles and responsibilities are discussed and defined.

Further discussion of the use of the Systems Engineering project for Thurston Smart Corridors is contained in **Tab C** of this report.

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TAB B:

DESCRIPTION OF PROPOSED IMPROVEMENTS

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Description of Proposed Improvements

1. Overview

The Smart Corridors project will implement new and upgraded field traffic signal control equipment, central traffic signal management software, and transit signal priority equipment along the Smart Corridors, as well as certain and intersecting arterials that are interconnected with Smart Corridors signals.

PROJECT ELEMENT	Upgrade / Replace Traffic Signal Controllers and / or Controller Cabinet Assemblies	Install Transit Signal Priority – Intersection Equipment	Install Transit Signal Priority – Onboard Equipment	Upgrade / Replace Central Traffic Signal Management Software	Upgrade / Replace Communications Systems
OLYMPIA	37 Intersections	Approximately 42 Intersections (Locations to be finalized during project design)	Approximately 15 Intercity Transit Fixed-Route Buses (Serving Routes 62 A/B and 13)	Upgrade Existing Central Software	As determined through project design
LACEY	24 Intersections			New Central Software	
TUMWATER	12 Intersections			–	
THURSTON COUNTY	4 Intersections			Linked to Lacey System	
WSDOT	9 Intersections			Linked to Lacey, Tumwater systems, Olympia, and Pacific Avenue	
TOTAL QUANTITY*	**86 Intersections**	**42 Intersections**	**15 Intercity Transit FR Buses**	**4 Jurisdictions**	**TBD**

*Approximate; quantities and device locations subject to finalization during project design

Exhibit B-1: Smart Corridors New and Upgraded Field Traffic Signal Control Equipment

Tab I includes a detailed inventory of proposed intersection improvements, including:

- Intersection locations, by jurisdiction
- Presence of Transit Service at the Intersection (for potential TSP activation)
- Connectivity to Central Traffic Signal Management Software (if any)
- Signal Interconnect Group (if any)
- Proposed Smart Corridors Upgrades / Replacements
- Owner/Operator/Maintainer of each signal

2. Summary of Selected Technology Alternatives

Agencies participated in a technology selection workshop, vendor demonstrations, and numerous discussions to determine the approaches that were most appropriate for meeting agency and regional objectives.

The RTOG compared a range of technology options and architectures as part of a comparative evaluation of suitability, functionality, and costs relative to the project need and resources. Details of this analysis are provided in **Tab H – Smart Corridors Technology Alternatives**.

The following table summarizes the technology alternatives selected, by jurisdiction:

AGENCY	SELECTED TECHNOLOGY ALTERNATIVES	KEY CONSIDERATIONS
City of Olympia	• Replace existing controller with 2070 controller operating software version 2033 • Upgrade existing McCain QuicNet central software to support TSP and enhanced coordination	• Maximize cost-effectiveness to cover a large number of signals with the available funding • Maintain a single traffic signal platform across the city for ease of maintenance • Upgrade existing systems and hardware to cost-effectively support TSP
City of Tumwater	• ASC/2 Controllers: Replace ASC/2 Controller with ASC/3 Controller • ASC/3 Controllers: Activate TSP logic in existing controllers • Traconex Controllers: Replace Controller Cabinet Assemblies with Econolite NEMA ASC/3 TS2 Type 1 Controller, or 2070 Controller operating ASC/3	• Objective to upgrade and standardize traffic signal control equipment through the Tumwater section of Capitol Boulevard • Current staffing levels preclude effective use of a new central traffic signal management system; investment deferred to a later date
City of Lacey	• Replace Controller Cabinet Assemblies with NEMA ASC/3 TS2 Type 1 Controller, or 2070 Controller operating ASC/3 • Implement New Central Traffic Signal Software	• Existing field hardware and central software is functionally obsolete and past useful life; need to replace complete cabinet assemblies and invest in a new central system • Maintain extensive signal coordination groups with intersect but reach well beyond the Smart Corridors boundaries
Thurston County	• Replace Controller Cabinet Assemblies with NEMA ASC/3 TS2 Type 1 Controller, or 2070 Controller operating ASC/3 • Potential interconnect to City of Lacey new Econolite Centracs Central System Software	• Maintain interoperability with City of Lacey who operates and maintain these signals as part of existing interconnect groups
WSDOT	• Lacey/Tumwater Operated: Replace Controller Cabinet Assemblies with NEMA ASC/3 TS2 Type 1 Controller, or 2070 Controller operating ASC/3; Potential interconnect to City of Lacey new Central System Software • Olympia Operated: Replace existing controller with 2070 controller operating software version 2033; activate TSP logic; Maintain integration with upgraded City of Olympia QuicNet	• Maintain interoperability with adjacent local jurisdictions that operate and maintain these signals as part of existing interconnect groups
Intercity Transit	• Installation of GPS/radio-based onboard TSP Logic, Emitter, and related components • Installation of radio-based roadside vehicle detection antenna/receiver and logic unit in signal controller cabinets at TSP intersections • Implementation of TSP central management software interfaced with Intercity Transit's scheduling software to support conditional priority	• Implementation of a conditional priority system capable of considering transit schedule adherence and traffic operational conditions in granting of a priority request • Accuracy and ease of maintenance of GPS/radio-based vehicle detection • Avoiding impacts in the existing emergency vehicle pre-emption system

Exhibit B-2: Technology Alternatives by Jurisdiction

3. Factors in Technology Selection

The Smart Corridors Regional Transportation Operations Group (RTOG) reviewed a wide range of technology options and configurations to meet the system requirements. The evaluation of technology alternatives considered many factors important to the success of the Smart Corridors project and the long-term operational sustainability of the systems:

- Meeting the near objectives and functional requirements for the Smart Corridors system
- Supporting future functional and physical expansion for the Smart Corridors system that support longer term operations objectives
- Ensuring interoperability of traffic signal systems within each jurisdiction, and with TSP across jurisdictions
- Implementing a cost-effective solution that balances system functionality with the overall affordability of the system
- Ensuring that agencies can operate and maintain those systems within existing, constrained resources
- Supporting future interoperability and enhanced traffic management functionality in the corridors

The table below summarizes major technology alternatives that were considered to support the project's high level operations.

SMART CORRIDORS SUB-SYSTEM	MAJOR TECHNOLOGY ALTERNATIVES CONSIDERED
Roadside Traffic Signal Control Equipment	• Upgrade existing traffic signal controllers • Replace controllers, keep existing cabinets • Replace complete controller cabinet assemblies
Central Traffic Signal Control and Management Software	• Implementation of a single, regional traffic signal control system • Upgrades/enhancements to existing traffic signal control software • Implementation of new traffic signal control software by jurisdiction • Do not implement central traffic signal control software
Transit Signal Priority (TSP)	• Implementation of unconditional TSP • Implementation of conditional TSP based on prevailing traffic conditions and/or schedule adherence • Use of Opticom infrared (IR) versus Unlicensed GPS / radio for TSP vehicle detection (vehicle to roadside communications)
Regional Data Analysis and Performance Measurement	• Developing Centralized data archive maintained by TRPC • Developing scaled down data retrieval and analysis system (data would simply be sent to TRPC for integration into the regional agency's models and other analysis tools)

Exhibit B-3: Major Technology Alternatives Sub-Systems

4. Rationale for Selecting Preferred Technologies

The technologies selected represent a mid-range alternative geared towards replacement and upgrade of system components to maximize performance at a mid-range cost point. This approach considers cost-effectiveness, reliability, near- and long-term functionality, and integration with adjacent parts of the regional traffic signal system.

Technology choices in the Cities of Tumwater and Olympia reflect the desire of the participating agencies for cost-effective solutions that make use of existing equipment (e.g. cabinets, controller assemblies) that is functionally sufficient and has useful remaining service life. Additionally, Olympia elected to implement a modest upgrade to its existing traffic signal control software rather than a substantially more expensive system replacement.

In the City of Lacey, existing Traconex signal equipment has exceeded its expected service life, and the selection of equipment represents a wholesale refresh of controller cabinet assemblies that will bring the City's infrastructure up to current standards while maintaining interoperability of its extensive interconnect groups across the City. Another important element in Lacey is the introduction of a new central traffic signal management software to support operations, configuration, maintenance, and performance measurement. Lacey's implementation is supported by the contribution of significant local funds to upgrade intersection equipment in the City.

Traffic signals operated by WSDOT and Thurston County will be upgraded to ensure interoperability with adjacent signals of the operating agencies (Olympia, City of Tumwater, and City of Lacey). This represents a continuation of existing partnerships and interlocal agreements for signal operations and maintenance.

The selection of a GPS / radio-based TSP System reflected national experience with the increased accuracy and reliability of this approach versus optical/infrared approaches. A GPS based approach will allow for more precise configuration and triggering of TSP requests with minimal ongoing maintenance responsibilities from the host traffic agencies (optical systems can require periodic receiver turret realigning and cleaning, and are also more difficult to aim to precise transit detection zones). Additionally, a radio-based system allows for remote transmission of system configuration, system health, and activity log data. This remote data transmission significantly reduces the level of operational effort required by participating agencies.

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TAB C:

SYSTEMS ENGINEERING PROCESS FOR THURSTON SMART CORRIDORS

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Systems Engineering Process for Thurston Smart Corridors

1. Introduction

This document describes the Regional ITS Architecture Consistency and Systems Engineering (SE) Process undertaken during the development of the Thurston Smart Corridors project.

Thurston Smart Corridors is funded through the use of Federal Congestion Mitigation and Air Quality (CMAQ) funds as well as required local agency contributions. FHWA, FTA, and WSDOT require that the Systems Engineering (SE) process must be applied to all ITS projects or projects with ITS elements. The Federal Requirement was established in Section 5206(e) of the Transportation Equity Act for the 21st Century (TEA-21).

On January 8, 2001 the FHWA Final Rule on ITS Architecture and Standards Conformity (Final Rule) and the FTA Final Policy on Architecture and Standards Conformity (Final Policy) were enacted. The Final Rule / Final Policy ensures that Intelligent Transportation Systems (ITS) projects carried out using funds from the Highway Trust Fund including the Mass Transit Account conform to the National ITS Architecture and applicable ITS standards (see 23 CFR 940.11).

Adherence to the Rule / Policy is accomplished through:

- The development of regional ITS architectures and their application at the project level; and
- The use of a SE process for ITS project development.

2. Systems Engineering (SE) Process Overview

According to one FHWA definition, Systems Engineering "integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs."

FHWA has established guidelines for the application of Systems Engineering for ITS projects to promote successful implementation and outcomes[1]. Additionally, WSDOT has adopted the SE process for ITS projects in the Department's Design Manual[2].

Key elements of the SE process are:

1. Using high-level business and functional requirements (desired outcomes) to drive the engineering design of the system;
2. Articulating the roles and responsibilities of participating agencies in the implementation and ongoing maintenance and operations of the system (which may be subsequently memorialized in written interagency agreements); and
3. Ensuring that the individual components and subsystems of the system that is implemented meets the high-level functional requirements identified at the outset of the project.

1 See Publication No. FHWA-HOP-07-069, Systems Engineering for ITS Handbook, Federal highway Administration, 2007.
2 See Manual M22-01, WSDOT Design Manual, Chapter 1050 "Intelligent Transportation Systems," July 2010.

The use of a SE process has a number of benefits to a complex technology project, including:

- Improved dialogue with system end user and capture of business requirements;
- Design of systems that are more responsive to user needs;
- Improved system functionality with fewer design defects;
- Reduce project costs due to design changes discovered late in the implementation process; and
- Improved post-implementation outcomes in operations and maintenance, including clarity in the roles and responsibilities of participating agencies.

The SE process is typically described in terms of a "Vee" diagram. The following figure illustrates the "Vee" diagram as well as the relationship to activities undertaken through the Smart Corridors project.

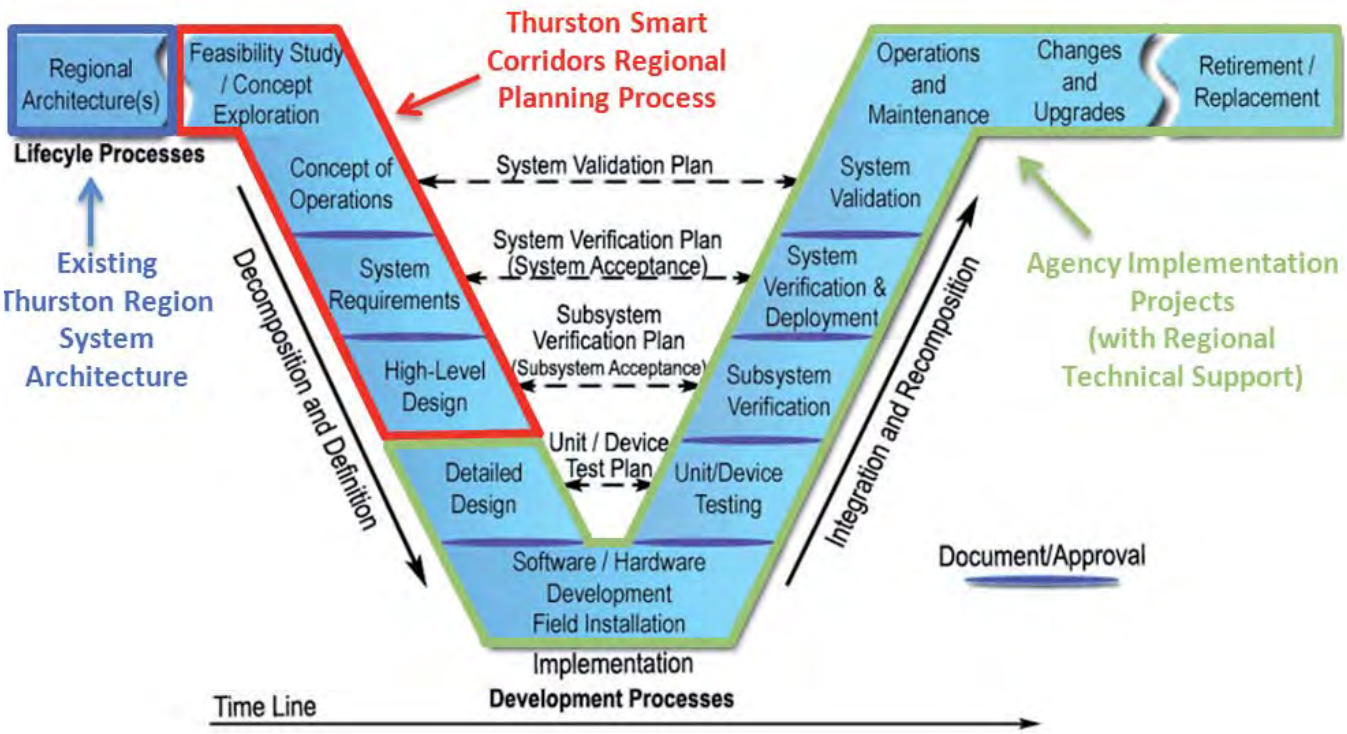

Exhibit C-1: The Systems Engineering "Vee" Diagram and Thurston Smart Corridors Process

3. Thurston Smart Corridors Systems Engineering Process

Planning for Thurston Smart Corridors followed the SE process to be consistent with UDSOT and WSDOT requirements, to manage the technical complexity of the project development process, and to ensure that user requirements and expectations were defined, documented, and ultimately fulfilled by the completed system.

The Thurston Smart Corridors SE Process consisted of the following steps:

SYSTEMS ENGINEERING STAGE	USE IN THURSTON SMART CORRIDORS	PROJECT DOCUMENTATION
Regional ITS Architecture	• Consistency review of the Thurston Smart Corridors project with the Thurston Regional ITS Architecture	• ITS Architecture Consistency Review
Feasibility Study / Concept Exploration	• Reviewed baseline conditions for arterial operations, transit operations, freeway incidents / detours, and special events to establish project need and objectives • Conducted one-on-one and group stakeholder visioning meetings / workshops to refine the Smart Corridors concept • Stakeholder site visit to the WSDOT Olympic Region Traffic Management Center to explore future freeway ATMS opportunities	• Baseline Conditions and Needs Assessment • Summary of Transit Operational Analysis (Memorandum)
Concept of Operations	• Definition of agency roles and responsibilities in implementation, operations, and maintenance • Development and discussion of typical operating scenarios	• Concept of Operations
System Requirements	• Definition of high-level functional requirements based on agency needs and market scans of available system capabilities	• High Level Functional Requirements
High Level Design	• Evaluated alternative technology concepts and system architectures for alternative technology approaches • Identified implementation intersections based on traffic operational needs, transit service locations, and traffic signal interconnects	• Smart Corridors Technology Assessment
Interagency Agreements	• Issued regional funding award letters specifying overall implementation budgets and regional project objectives • Reviewed existing traffic signal interlocal agreements to ensure suitability for meeting Smart Corridors Objectives • Developed Letter of Intent for implementation of regional TSP	• Existing Agency Interlocal Agreements • TSP Letter of Intent

Exhibit C-2: Thurston Smart Corridors SE Process

Upon the completion of this regional planning process and the award of regional funds by TRPC to the implementing agencies, the continued implementation of the SE process (e.g. detailed design, testing, validation, and verification, as well as post-implementation operations and maintenance) rests with the individual implementing agencies.

4. Regional ITS Architecture Compliance

A related Federal requirement is that Federally-funded ITS projects are consistent with the regional ITS Architecture. The Regional ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems across agencies and modes, to maximize functionality and interoperability of those systems.

To ensure that the Thurston Smart Corridors project is consistent with the regional ITS architecture for the Thurston Region, an analysis of project requirements against the existing regional ITS architecture was conducted (and is described elsewhere in this report).

The current regional ITS Architecture for Thurston County is known as the *Thurston Region System Architecture* and was developed in 2002. The Regional ITS Architecture was developed under the supervision of the Thurston Regional Planning Council is maintained by TRPC. All applicable ITS functionality (Service Packages, formerly Market Packages) for the Smart Corridors project is contained within the Regional ITS Architecture. Additionally, WSDOT maintains a Statewide ITS Architecture describing interactions with WSDOT-owned ITS systems.

Regional ITS Architecture compliance is discussed further in a separate section of this report.

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Baseline Conditions and Needs Assessment

1. Introduction

1.1. Purpose

This document summarizes baseline conditions and needs for the Thurston Regional Planning Council (TRPC) "Smart Corridors" initiative. Based on the existing conditions and needs identified, this document identifies candidate technology alternatives to improve corridor operations, mobility, and safety for multimodal transportation system users.

Smart Corridors is a technology-based initiative to improve multimodal transportation operations in key urban arterial corridors in Thurston County. Potential technology applications include traffic signal coordination and optimization, TSP, regional data analysis and performance measurement, and integrated arterial / freeway management of incidents and planned / unplanned events.

Smart Corridors will identify operational needs and performance measures to evaluate candidate technologies, determining the most appropriate solutions for Thurston County. A Regional Concept of Operations will address the institutional issues associated with new technologies, ensuring successful implementation, operation, and maintenance of the system.

Planning, design, and implementation for Smart Corridors is funded through a $2.1m Congestion Mitigation and Air Quality (CMAQ) grant.

Two Smart Corridors have been identified for analysis under this project:

- 4th Avenue / State Avenue (Olympia) to Martin Way / Marvin Road (Lacey)
- Capitol Way / State Avenue / (Olympia) to Capitol Boulevard / Tumwater Boulevard (Tumwater)

2. Arterial Operations – Base Line Conditions

2.1. Existing Field Equipment

A detailed summary of existing signal equipment in the region, based on information collected from participating agencies is included in Appendix I2.

Controllers, controller software, communications infrastructure, central control capabilities, detection, cabinet types, and phasing plans vary among the four signal operating agencies in Thurston County: WSDOT, City of Olympia, City of Lacey, and City of Tumwater.

Many of the devices active in the field are nearing the end of their service life or are functionally deficient with respect to modern advanced traffic management functionality. The variety of platforms and hardware devices in use in the region curtails the ability to implement regional traffic signal control strategies across jurisdictional boundaries:

- The City of Olympia operates Type 170 controllers operating with Bitrans 233 rev 2.8b software. Signals are interconnected with copper wire and operate under the QuicNet 4 central control software. A variety of video loop, microwave, and pedestrian push button detection is in use within the City.
- The City of Lacey operates Traconex TMP-390 controllers with a majority of signals on the Traconet J3 central control system. The system is not well supported by the vendor and runs on an older Windows 98 operating system. A combination of video and induction loop detection is used.
- In the City of Tumwater, the City is migrating to a fiber-interconnected system using an Econolite Aries master controller and envisions a future in-house city traffic control center. The Traffic Management Center (TMC) would be used to activate alternative timing plans and to diagnose equipment problems in the field. However, a variety of ASC2 and ASC3 controllers (mostly Econolite and Traconex) is still in operations in the Corridors. Five signals in the Tropser Road are interconnected, thought the state has jurisdiction over two ramp signals.
- Statewide, WSDOT is migrating from Traconex controllers to 2070 controllers with Econolite Oasis software; however, the Traconex controllers are still in use in the two WSDOT controllers located on the Martin Way corridor. Lacey is responsible for timing these two signals, subject to WSDOT approval of the timing plans.
- Thurston County is unique in that while it owns five (5) signals in the Martin Way corridor, these are maintained under contract to the City of Lacey.

All signals in the two Smart Corridors are outfitted with Opticom non-encoded emergency signal pre-emption (ESP) receivers for emergency management operations.

2.2. Operational Issues and Bottlenecks

A number of intersections along the Smart Corridors are described anecdotally as traffic bottlenecks, particularly during peak periods or following activation of the ESP system. Some of the most problematic locations mentioned by RTOG members include:

- Capitol Boulevard / Trosper Road (Tumwater)
- Martin Way / Lilly Road (Olympia)
- Martin Way / Sleater Kinney Road (Olympia)
- Martin Way / College Street (Lacey / Olympia)
- Martin Way / I-5 Exit 109 (Lacey)

Recovery and mitigation of the secondary impacts of ESP activation is a key traffic operational concern of the region. For example, in Tumwater, controllers are programmed to serve the priority movement after ESP activation. Multiple activations in a short period can result in a failure to service secondary movements for a

considerable period. In all jurisdictions, recovery from peak period ESP activations to normal conditions can require the remainder of the peak period.

I-5 incidents can cause significant traffic volumes to divert onto the parallel arterial corridors. Because the arterial system does not have the slack capacity to absorb this surge in demand, traffic operations on the corridor rapidly deteriorate, sometimes for extended periods of time. Municipalities do not have the capability to systematically adjust timing plans to give priority to diversion routes to mitigate the impacts on their communities.

It is worth noting that the City of Lacey's primary traffic considerations are the higher-volume north-south movements on arterials such as College Street and Marvin Road, which is a WSDOT owned facility (SR 510). As a result, the operation of Martin Way is sacrificed in order to optimize the performance of these perpendicular corridors.

2.3. Agency Capabilities and Practices

Operational Practices, policies, and resources vary among the agencies operating traffic signals and related infrastructure in Thurston County. For most jurisdictions, in-house capabilities and resources to support traffic signal maintenance and integration is limited or informal.

With the exception of Thurston County, which contracts out its signal operations, each of the operating jurisdictions has some level of in-house traffic signal technical and maintenance capabilities:

- The City of Olympia has 1.5 full-time equivalents (FTEs) for traffic signal maintenance.
- The City of Lacey has the highest level of resources of the cities in the region, with 3 signal technicians and two signal engineers capable of developing signal timing plans in-house.
- The City of Tumwater has less than 1 FTE.

WSDOT has a staff of five responsible for 275 signals in Olympic region, only two of which are located within the study area (Martin Way).

2.4. FHWA Review of Regional Traffic Signal Operations

In January 2009, the Federal Highway Administration (FHWA) conducted an assessment of Thurston County's Regional Traffic Signal Operations Program. The goal of the assessment was to evaluate the operational practices of individual agencies in order to provide guidance for the creation of a sustainable regional traffic signal management program, focusing on policies, processes, and practices rather than infrastructure deployment.

The assessment included the RTOG agencies of: City of Olympia; City of Lacey; City of Tumwater; TRPC; WSDOT Olympic Region; Intercity Transit; and Thurston County. Participating agencies completed a questionnaire providing information on their technical and institutional capabilities and participated in interviews and workshops with FHWA staff.

The final report[1] of this assessment provides a detailed overview of existing signal traffic signal operations programs and is included here by reference.

Key Observations and Recommendations identified in the FHWA assessment are summarized in the table below. Other noteworthy observations of the assessment include:

- The informal nature of regional traffic signal operations and multi-agency working relationships
- The 'maintenance-centric,' nature of agency programs intent on keeping systems functional, rather than on system operational performance
- Initial efforts to formalize traffic operations as a core agency function
- The lack of a common, up-to-date technology standard for traffic signal hardware and software platforms to support modern functionality

1 Federal Highway Administration. "Assessment of Thurston County Regional Traffic Signal Operations Program." September 2009.

Additional details are available in the final report accompanying the assessment.

	OBSERVATION	RECOMMENDATION
1	A Good Foundation Exists in the commitment, dedication and professionalism of staff	• Maintain, Reinforce and Expand this Foundation
2	Documentation Describing Operations Policies, Objectives and Practices Missing	• Develop and Implement Regional Transportation Concept of Operations • Develop Regional Operations Objectives, and Performance Policies
3	Lack of System Performance, Measuring and Monitoring	• Adopt and Implement Regional Performance Monitoring Program
4	Staffing Levels, Staff Functions, Qualifications and Training Needs Are Not Well Defined	• Create a Standard for Personnel Certification /Qualification /Develop and Support Training Needs
5	Little Regional Information Sharing, Signal Timing Practices Are Not Consistent Regionally	• Build Stronger Regional Relationships And Programs To Share Information, Standardize Signal Timing Practices Within The Region
6	Many Regional Systems Are Near The End of Their Useful Service Life	• Replace Outdated Equipment With New Regional Standard
7	No Well Known and Tested Incident Management Plans for Coordinated Signal Control	• Develop and Regularly Exercise Regional Plans
8	Inadequate Funding for Traffic Operations	• Craft Program of Sustainable Funding for Traffic Operations

Exhibit D-1: FHWA Regional Traffic Signal Operations Program Assessment (2009) Observations and Recommendations

3. Emergency Management Considerations

3.1. Emergency Signal Pre-emption (ESP) System

Emergency Signal Pre-emption (ESP) is widely deployed in the study region and has been a successful deployment since the 1990s. The system uses unencoded Opticom technology and replaces a former radio tone based system. Much of the Opticom field equipment is believed to be original. ESP equipment is used by both fire and police responders in most jurisdictions in the region.

The system is operated through button activation of the emitter in the cab of the vehicle. There are receivers outside of fire stations to activate signals during vehicle pull-out. The system is used only when running with lights and sirens. Systems are interlocked to deactivate when vehicles are in park, but there is an override to activate without lights and sirens. Anecdotally, police activate the system without lights much more often than the fire system as their operational needs are different from those of fire.

While the system is generally reliable, failures are recognized to significantly impact responding agencies and the public in need of assistance. Participating agencies have formal mutual aid agreements but no formal technology agreements. The City of Olympia, for example, contacts public works when it identifies a maintenance issue that cannot be addressed by its own onboard technician.

The biggest perceived challenge is when there are multiple vehicles approaching a given intersection and ensuring that approaching emergency response vehicles do not collide due to failure to heed confirmation lights or red signals. If the confirmation light is on but the approach light is red, this implies that another approach has already been granted preemption.

Emergency vehicle preemption activity can have a significant impact of traffic operations, particularly during peak periods. The City of Olympia, for example, has three fire stations and averages 30 calls per day.

3.2. Freeway Incident Response by Local Jurisdictions

Local jurisdictions including Olympia, Lacey, and Tumwater are responsible for incident response on the I-5 / US 101 freeways. The Washington State Patrol and WSDOT are responsible for traffic management of those incidents.

The Thurston 9-1-1 Communications has video monitors to see DOT camera feeds as part of incident response.

Current, limited camera coverage does not allow for incident verification but would be of interest. Video would have been a significant asset during the recent earthquake. Emergency response agencies would be interested in using video for verifying route choice, which is done now anecdotally by time of day (e.g. choice to avoid the freeway after 3:30 pm).

4. Freeway Operational Impacts on the Smart Corridors

4.1. WSDOT Traffic Management Center

WSDOT manages traffic operations on state highways in the study region from the Olympic Region Traffic Management Center (TMC), also known as "Olympic Radio," located in Pierce County. Functions include traffic / congestion management, traveler information, incident response and management, and emergency response functions, among other responsibilities.

WSDOT currently is unable to centrally control WSDOT-owned traffic signals in the study corridors from its TMS location. However, the TMS does control other ITS devices and has developed incident management plans and detours as described below.

4.2. Freeway Operations and the Smart Corridors

Due to the proximity of both of the Smart Corridors to I-5, and to a lesser extent US 101, freeway performance and disruptions (incidents, closures, and construction) can detrimentally impact Smart Corridor arterial operations.

MONTH	INCIDENT CATEGORY DESCRIPTION	I-5 EVENTS	US 101 EVENTS	MONTH	INCIDENT CATEGORY DESCRIPTION	I-5 EVENTS	US 101 EVENTS
April	Cable Barrier	2		June	Bridge	2	
April	Closure	14		June	Closure	30	
April	Collision	6	1	June	Collision	14	1
April	Construction	34		June	Construction	32	1
April	Dead Animal	3		June	Dead Animal	11	2
April	Debris	7	1	June	Debris	6	
April	Disabled vehicle	1		June	Fire	2	
April	ITS & IT	2	1	June	ITS & IT	1	
April	Maintenance	10	1	June	Maintenance	32	7
April	Other	3		June	Other	33	1
April	Pierce Co. Roads	1		June	Signs		1
April	Signs	2		June	Trees	2	
April	Water over Roadway	2			TOTAL	165	0
	TOTAL	87	4	July	Bridge	4	
May	Administrative	1		July	Cable Barrier	1	1
May	Bridge	1	1	July	Closure	18	2
May	Closure	15	2	July	Collision	8	
May	Collision	16	5	July	Construction	31	
May	Construction	30	2	July	Dead Animal	4	2
May	Dead Animal	6		July	Debris	7	3
May	Debris	2	1	July	Disabled vehicle	1	1
May	Disabled vehicle	4	1	July	Fire	2	
May	ITS & IT	3		July	Maintenance	17	1
May	Maintenance	22	8	July	Other	1	
May	Other	36		July	Signs	3	
May	Slides		1	July	Trees	1	
May	Water over Roadway	1	1		TOTAL	98	0
	TOTAL	137	24		TOTAL EVENTS	487	24

Exhibit D-2: I-5 and US 101 Freeway Incidents, Thurston County, April-July 2009

Freeway incidents that lead to significant delays or blockages can send spillover traffic onto arterial streets of adjacent cities, saturating these arterials and causing negative impacts on traffic operations, mobility, and quality of life in these communities until normal operations is restored and spillover traffic is eliminated.

The table shown here summarizes the classification and frequency of incidents responded to by WSDOT's Incident Response Team over a typical four-month period between April and July, 2009.

It is noteworthy that local fire departments and districts are involved in incident response for freeway incidents through mutual aid agreements with WSDOT and the Washington State Patrol. As such, traffic gridlock and delays on adjacent arterials impede the emergency response process, worsening traveler delays and threatening life and property during these types of incidents.

4.3. WSDOT Incident Management Handbook and Detours

WSDOT has established incident response protocols for managing severe incidents. The Incident Management Handbook for I-5 in the Thurston County Region provides for a coordinated response of state and local agencies for incidents that block all freeway lanes in one direction and are anticipated to last for two hours or more.

The plan involves the Thurston County Sheriff and Road and Transportation Services; DPW and Police from the Cities of Lacey, Olympia, and Tumwater; Thurston 9-1-1 Communications; TRPC and several fire districts and departments. Coordination with Pierce and Lewis Counties to the north and south is planned in the future.

The plan is available through the Rapid Responder secure emergency responder website, providing electronic access to the plan and its contents to a variety of respondents under incident response conditions.

A series of prescribed detour routes has been developed to support the Incident Management Plan, which are accompanied by flip signs in the field to provide direction to motorists diverted from the Interstate.

Both Smart Corridors are impacted by designated detour routes (as well as informal detouring by motorists seeking to circumvent incident congestion), due to their proximity and routing that roughly parallels I-5.

Capitol Way is also impacted by several US 101 diversion routes between Trosper Road and Custer Way, though Tumwater Boulevard and Henderson Boulevard serve as an alternative reliever for I-5 detours south of downtown Olympia.

The map in *Exhibit D-3* illustrates WSDOT detour routes for the Smart Corridors region.

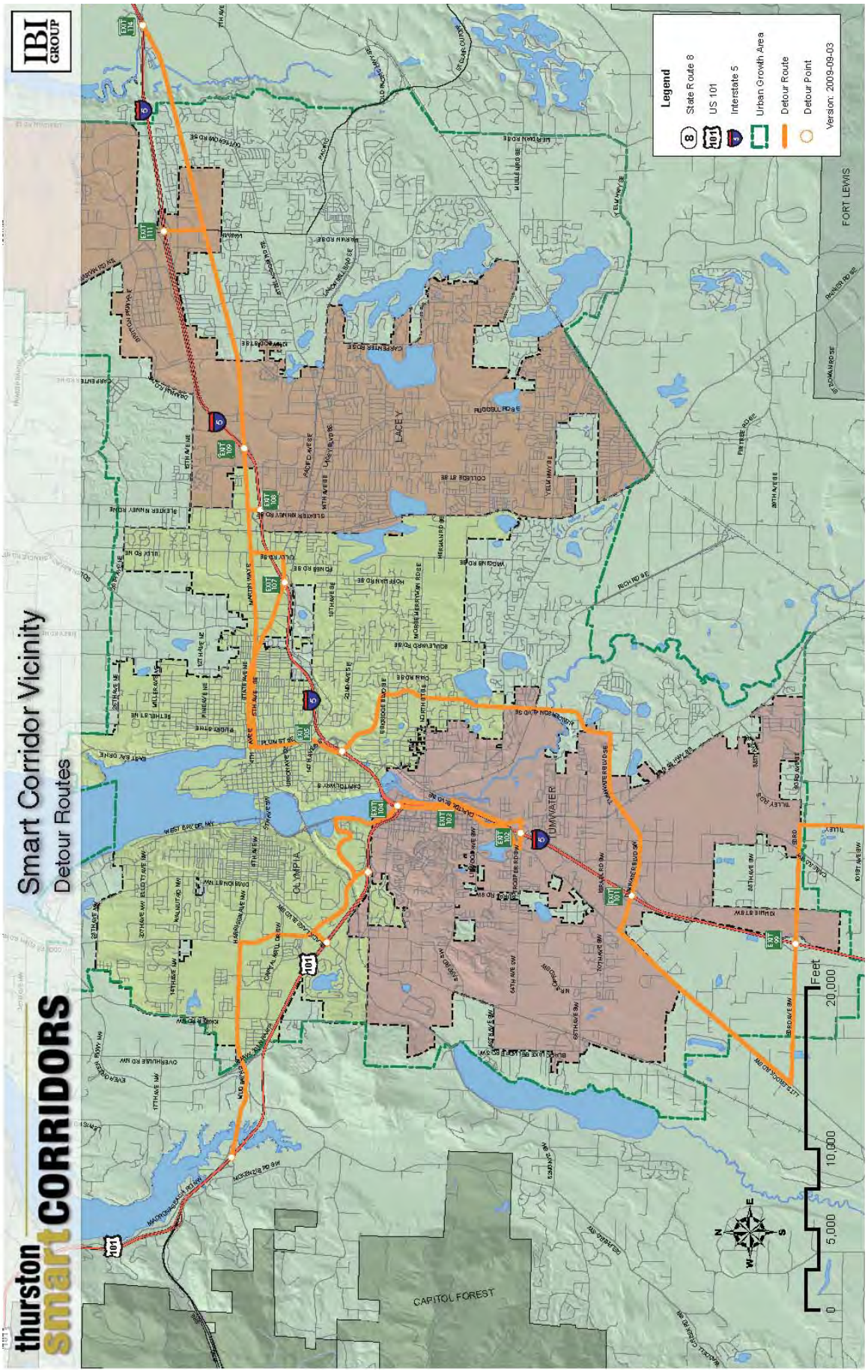

Exhibit D-3: WSDOT Detour Routes Map for the Smart Corridors Region

4.4. Capitol Boulevard Detour Routes

Because of its proximity to the junction of the I-5 and US 101 freeways (Exits 103-104), Capitol Boulevard / Capitol Way figure prominently into several WSDOT detour plans. These diversion routes are clustered primarily around the junction of the I-5 / US 101 facilities.

Henderson Boulevard SE provides an alternative detour route parallel to Capitol Boulevard for incidents along the north-south segment of I-5 in Tumwater and Olympia. Henderson Boulevard is the preferred WSDOT detour in several of its plans, in part due to lower levels of congestion under routine and incident conditions as compared to the Capitol corridor. The Capitol Boulevard Detour Routes are described and illustrated in the following table and figure, respectively.[2]

2 Source: WSDOT Olympic Region

NB = NORTHBOUND SB = SOUTHBOUND			SMART CORRIDOR			
Detour Number	Detour Name (includes direction and milepost numbers)	Streets Used	Smart Corridor Used	Enter	Exit	Distance Travelled within
13	NB: I-5, 102.6 - 104.6	Trosper Road Capitol Boulevard E Street Deschutes Way	Capitol	Trosper Road and Capitol Boulevard	Capitol Boulevard and E Street	0.86 miles
18	NB: I-5, 101.0 – 106	Tumwater Boulevard Henderson Boulevard Plum Street	Crosses Capitol	use I-5 Exit 101 (Tumwater Boulevard) to travel North on Henderson Boulevard to Exit 106 - cross over Capitol Boulevard travelling East	cross through the intersection of Tumwater and Capitol	
19	SB: I-5, 106.1 - 100.9	Plum Street Henderson Boulevard Tumwater Boulevard	Crosses Capitol	use I-5 Exit 105B to travel South on Henderson Boulevard to Tumwater Boulevard (Exit 101) - cross over Capitol Boulevard travelling West	cross through the intersection of Tumwater and Capitol	
37	SB: US 101 366.2 - I-5 102.6	Cooper Point Dr Evergreen Park Dr Lakeridge Dr Deschutes Way/Pkwy E Street Capitol Boulevard Trosper Road	Capitol	E Street and Capitol Boulevard	Capitol Boulevard and Trosper Road	0.85 Miles
47	SB: US 101, 365.1 - I-5, 102.6	Mud Bay Road Cooper Point Dr Evergreen Park Dr Lakeridge Dr Deschutes Way/Pkwy E Street Capitol Boulevard Trosper Road	Capitol	E Street and Capitol Boulevard	Capitol Boulevard and Trosper Road	0.85 Miles

Exhibit D-4: Capitol Corridor: WSDOT Pre-Planned Freeway Detours

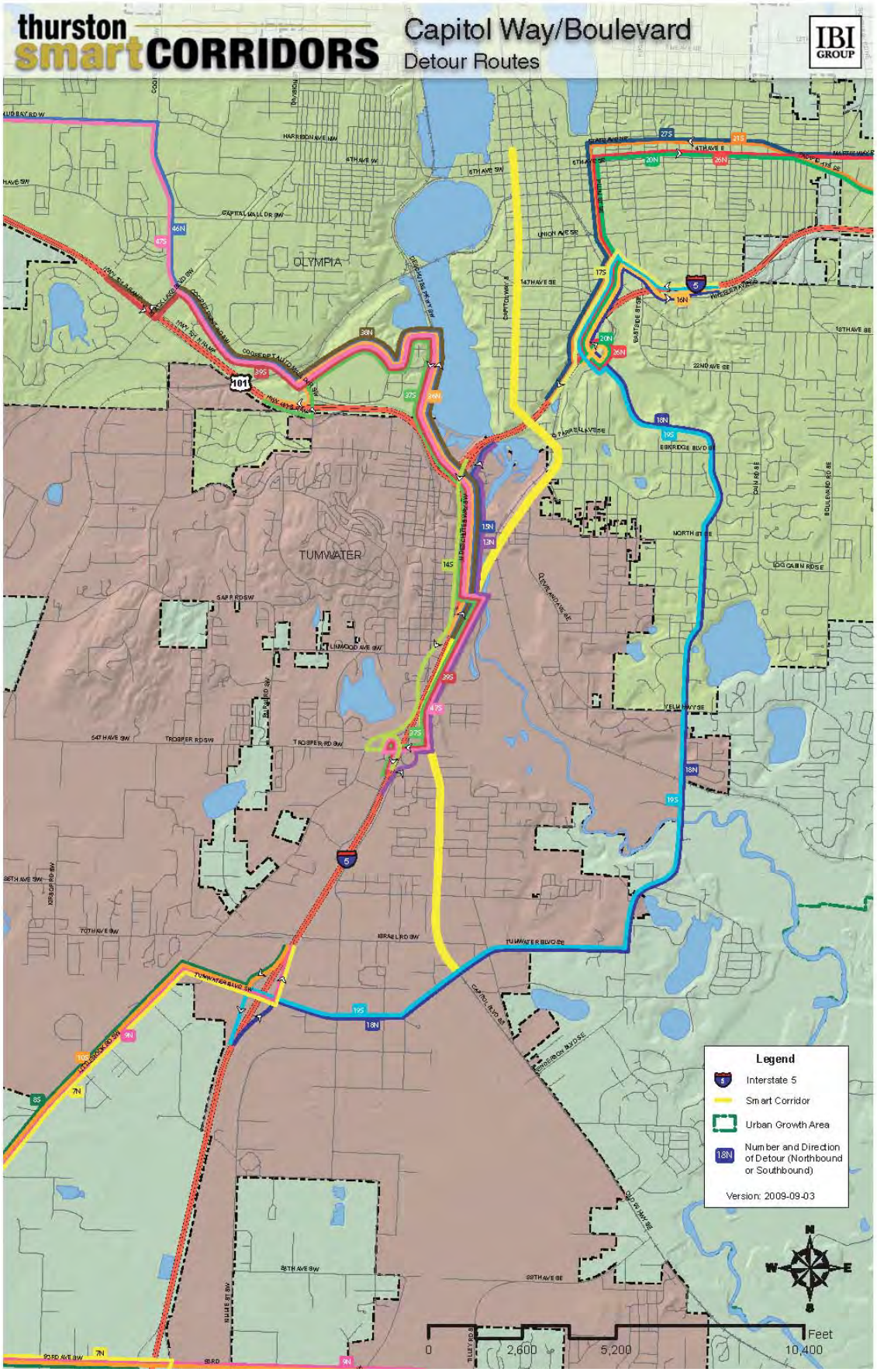

Exhibit D-5: Capitol Boulevard Detour Routes Map

4.5. Martin Way Detour Routes

Like the Capitol corridor, the Martin Way corridor is parallel to I-5 for much of its length with multiple freeway interchanges. Some of these detours traverse the Martin Way corridor and perpendicular feeders for considerable distances.

Certain diversion routes use the Plum Street / State Street / 4th Avenue corridors close to the downtown Olympia core. The Martin Way Detour Routes are described and illustrated in the following table and figure, respectively[3].

NB = NORTHBOUND SB = SOUTHBOUND			SMART CORRIDOR			
Detour Number	Detour Name (includes direction and milepost numbers)	Streets Used	Smart Corridor Used	Enter	Exit	Distance Travelled within Smart Corridor
20	NB: I-5, 105.2 - 107.7	Henderson Boulevard Plum Street 4th Avenue Pacific Avenue	Martin	4th and Plum	Martin and Pacific	1.05 miles
21	SB: I-5, 107.7 - 104.9	Pacific Avenue State Avenue Plum Street Henderson Boulevard	Martin	Martin and Pacific	State and Plum	1.07 miles
22	NB: I-5, 107.7 - 109.4	Pacific Avenue Lilly Road Martin Way	Martin	Lilly Road and Martin Way	Martin Way and I-5 Exit 109	1.29 miles
23	SB: I-5, 109.3 - 107.1	Martin Way Lilly Road Pacific Avenue	Martin	I-5 Exit 109 and Martin Way	Martin Way and Lilly Road	1.13 miles
34	NB: I-5, 109 - 114.5	Martin Way	Martin	I-5 Exit 109 and Martin Way	Martin Way and Marvin Road	2.35 miles
35	SB: 114.5 - 108.8	Martin Way	Martin	Marvin Road and Martin Way	Martin Way and I-5 Exit 109	2.69 miles

Exhibit D-6: Martin Corridor: WSDOT Pre-Planned Freeway Detours

3 Source: WSDOT Olympic Region

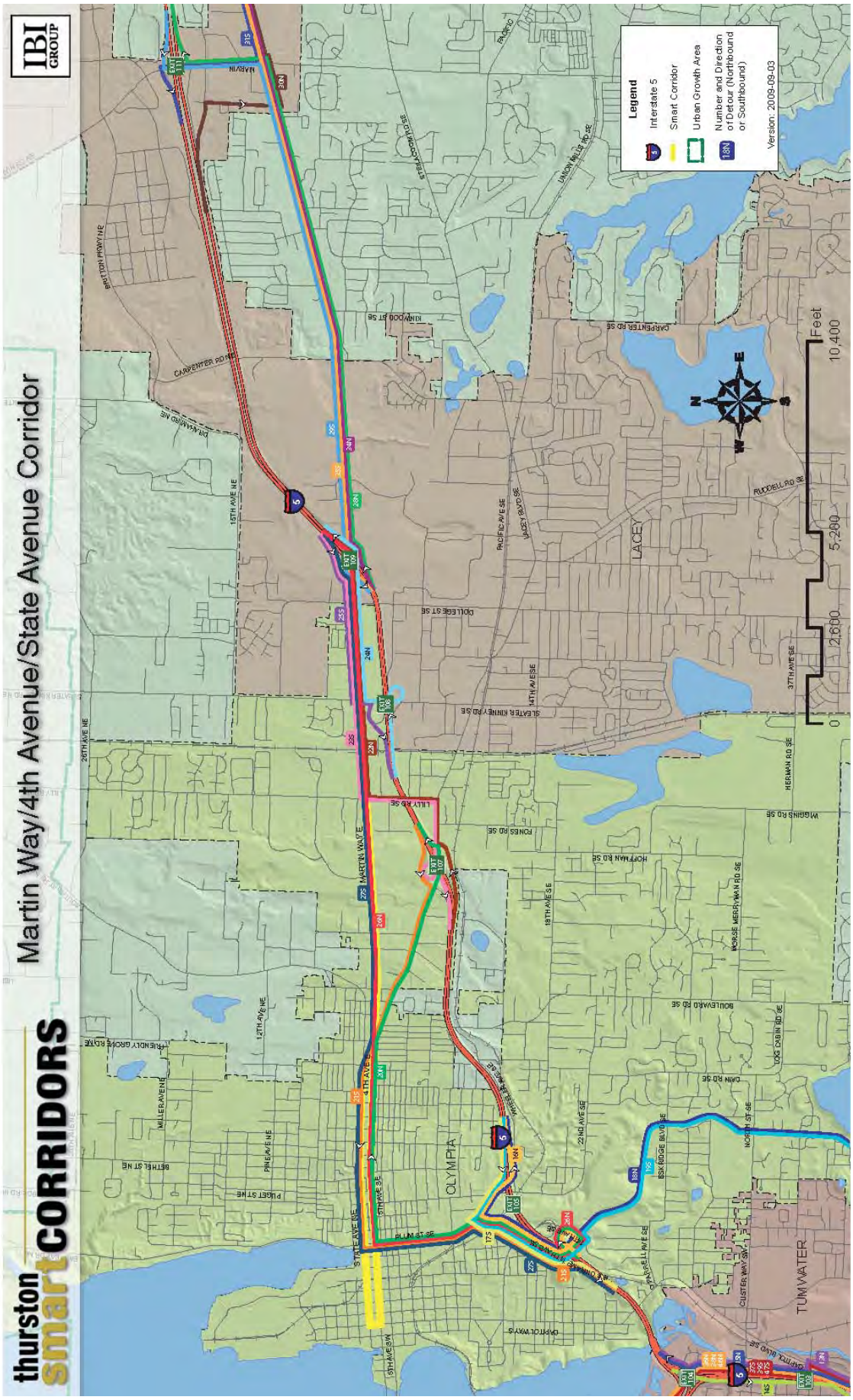

Exhibit D-7: Martin Way Detour Routes Map

4.6. Non-Corridor Detour Routes

For completeness, WSDOT detours that do not directly impact the Smart Corridors are listed in the following table. Of course, secondary impacts of incident and detour conditions can also impact the Smart Corridors given their physical proximity and the relatively few alternative arterial travel options in the region[4].

NB = NORTHBOUND SB = SOUTHBOUND			SMART CORRIDOR			
Detour Number	Detour Name (includes direction and milepost numbers)	Streets Used	Smart Corridor Used	Enter	Exit	Distance Travelled within Smart Corridor
7	NB: I-5, 99 - 101	93rd Avenue Littlerock Road Tumwater Boulevard	None	—	—	—
8	SB: I-5, 101 - 99	Tumwater Boulevard Littlerock Road 93rd Avenue	None	—	—	—
9	NB: I-5, 95 - 101	Maytown Road Tilley Road 93rd Avenue Littlerock Road Tumwater Boulevard	None	—	—	—
10	SB: I-5, 101 - 95	Tumwater Boulevard Littlerock Road 93rd Avenue Tilley Road Maytown Road	None	—	—	—
14	SB: I-5, 104.3 - 102.6	N 2nd Avenue SW	None	—	—	—
15	NB: I-5, 103.4 - 104.6	Deschutes Way	None	—	—	—
16	NB: I-5, 105.2 - 106	Henderson Boulevard Plum Street	None	—	—	—
17	SB: I-5, 106.1 - 104.9	Plum Street Henderson Boulevard	None	—	—	—
32	NB: I-5, 113.9 - 116.9	Nisqually Cut-off Road Kuhlman Road Old Pacific Highway	None	—	—	—
33	SB: I-5, 117.2 - 113.8	Old Pacific Highway Kuhlman Road Nisqually Cut-off Road	None	—	—	—
36	NB: US 101, I-5 103.4 - US 101 366.2	Deschutes Way / Pkwy Lakeridge Dr Evergreen Park Dr Cooper Point Dr	None	—	—	—
38	NB: I-5, 103.4 - US 101 365	Deschutes Way / Pkwy Lakeridge Dr Evergreen Park Dr Cooper Point Dr / Road Black Lake Boulevard	None	—	—	—
46	NB: I-5, 103.4 - US 101 362.4	Deschutes Way / Pkwy Lakeridge Dr Evergreen Park Dr Cooper Point Dr Mud Bay Road	None	—	—	—

Exhibit D-8: Other WSDOT Pre-Planned Freeway Detours

4 Source: WSDOT Olympic Region

4.7. WSDOT ITS Devices in Thurston County

Aside from state-operated traffic signals, WSDOT maintains a number of Highway Advisory Radio (HAR), Variable Message Sign (VMS), and Closed-Circuit Television (CCTV) devices that support its traffic operations programs.

A summary of these device locations in Thurston County is provided below[5]. Note that WSDOT operates three CCTV cameras on the Martin Way Smart Corridor (at College and Sleater Kinney), with a third arterial street location in Olympia at the intersection of Union and Plum Streets near the Milepost 105 A / B Interchanges on I-5.

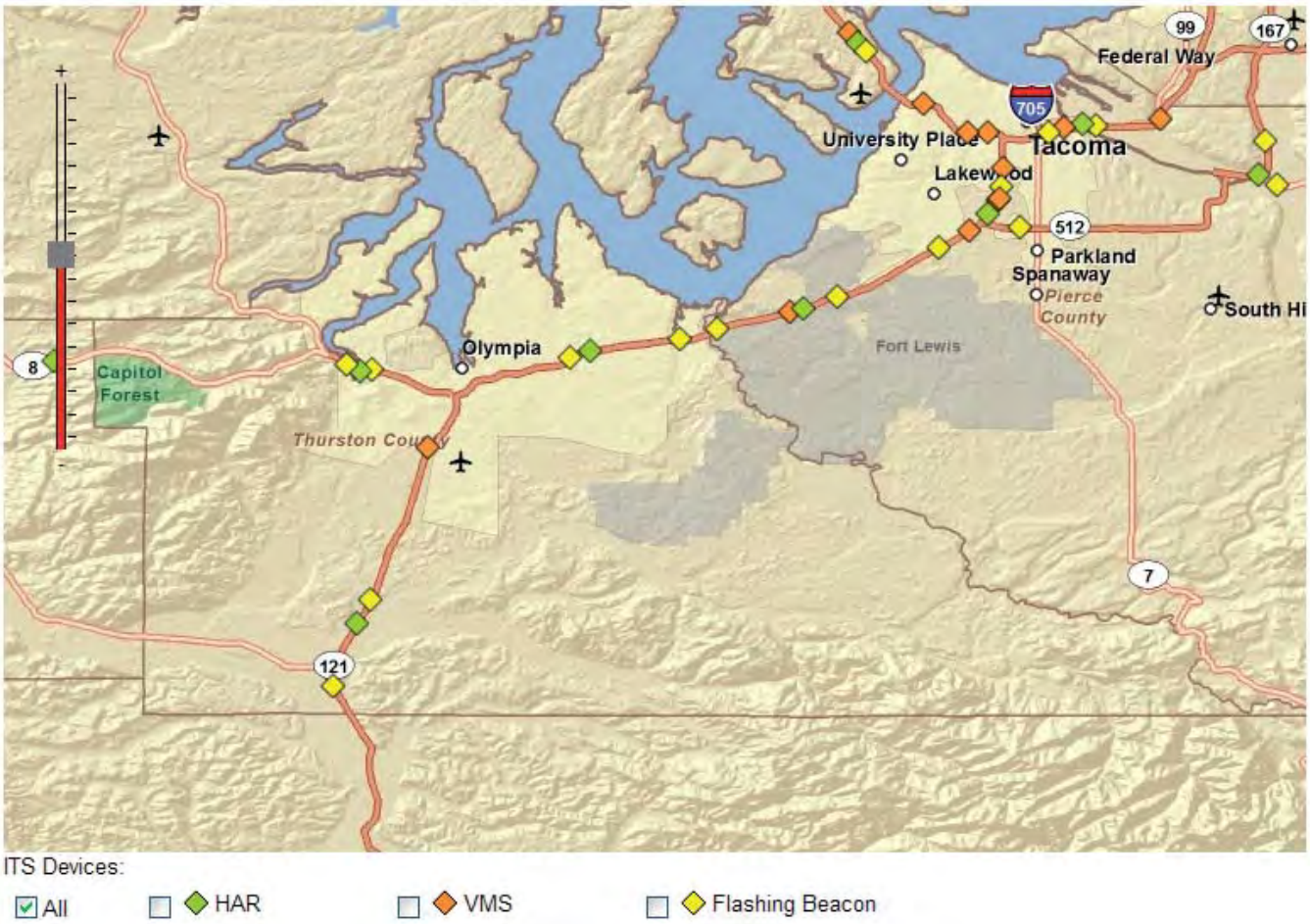

Exhibit D-9: WSDOT ITS Device Locations in Thurston County

5 Source: WSDOT Olympic Region

HIGHWAY ADVISORY RADIO (HAR), BEACON (HARS) AND VARIABLE MESSAGE SIGN (VMS)				
ROUTE	MILEPOST	DEVICE	DIR	Location
I-5	87.1	HARS	NB	Scatter Creek NB Flasher
I-5	90.9	HAR	NB	Scatter Creek HAR
I-5	92.3	HARS	SB	Scatter Creek SB Flasher
I-5	101.28	VMS	NB	Tumwater Boulevard.
I-5	109.5	HARS	NB	Lacey NB Flasher
I-5	110.4	HAR	SB	Lacey HAR
I-5	113.9	HARS	SB	Lacey SB Flasher
*Note: There is an additional southbound VMS on I-5 in southern Pierce County				
SR 8	4.6	HARS	EB	SR--8 EB Flasher McNight Road
SR 8	9	HAR	L	SR-8 HAR
US 101	362.6	HARS	NB	Mud Bay NB Flasher
US 101	363.7	HAR	SB	Mud Bay HAR
US 101	363.7	HARS	NB	Mud Bay NB Ramp Flasher

CLOSED-CIRCUIT TELEVISION (CCTV) – FREEWAY LOCATIONS	
ROUTE / LOCATION	MILEPOST
I-5 @ Custer Way	104.04
I-5 @ Capitol Boulevard	104.8
I-5 @ Eastside	105.67
I-5 @ Pacific Avenue	107.2
I-5 @ Slater Kinney	108.39
I-5 @ Martin Way	109.15
I-5 @ Nisqually	114.1
US 101 @ Crosby	366.64

WSDOT CLOSED-CIRCUIT TELEVISION (CCTV) – ARTERIAL LOCATIONS
College Street @ Martin Way (Lacey)
Sleater Kinney Road @ Martin Way (Lacey)
Union @ Plum Street (Olympia)

Exhibit D-10: WSDOT ITS Device Locations in Thurston County

5. Transit Operations – Baseline Conditions

Intercity Transit (IT) operates fixed-route and demand-responsive transit in the Greater Olympia region. The Martin and Capitol Smart Corridors are key trunk corridors for regional transit, accounting for a significant amount of the agency's passenger volumes and revenue service.

This section presents an analysis of Intercity Transit operations in the Martin Way and Capitol Way Smart Corridors. This analysis is derived from data provided to the study team by Intercity Transit, including detailed data on schedules and travel times, route hours and mileage, ridership by route, ridership by stop, and historical on-time performance. This data was collected in 2009 through a combination of Automatic Passenger Counter (APC) data as well as onboard ride checks by Intercity Transit staff.

5.1. Intercity Transit CAD / AVL System

Of interest to the Smart Corridors Initiative, Intercity Transit has implemented a Computer Aided Dispatch / Automatic Vehicle Location (CAD/AVL) system to improve transit dispatch, service monitoring, and maintenance and restoration of service. This system went live in 2009 and is currently undergoing testing and refinement. At the time of writing, archival operations data from the CAD/AVL system was not available for transit operations analysis. The CAD/AVL system provider is ACS (formerly Orbital, and subsequently purchased by and operating as a division of the Xerox Corporation).

The CAD/AVL system provides the underlying transit systems intelligent (e.g. real-time schedule adherence based upon GPS vehicle position data) that can support future transit signal priority (TSP) deployment as well as other enhanced transit management functionality.

Data derived from the CAD/AVL system, when available for analysis, can provide a vast amount of information on detailed operating conditions in the Intercity Transit system (e.g. transit travel time variability). This resource should be kept in mind as the Smart Corridors project, specifically Transit Signal Priority elements, advances into the design stage.

Exhibit D-11 on the next page illustrates Intercity Transit Routes within the Smart Corridors region.

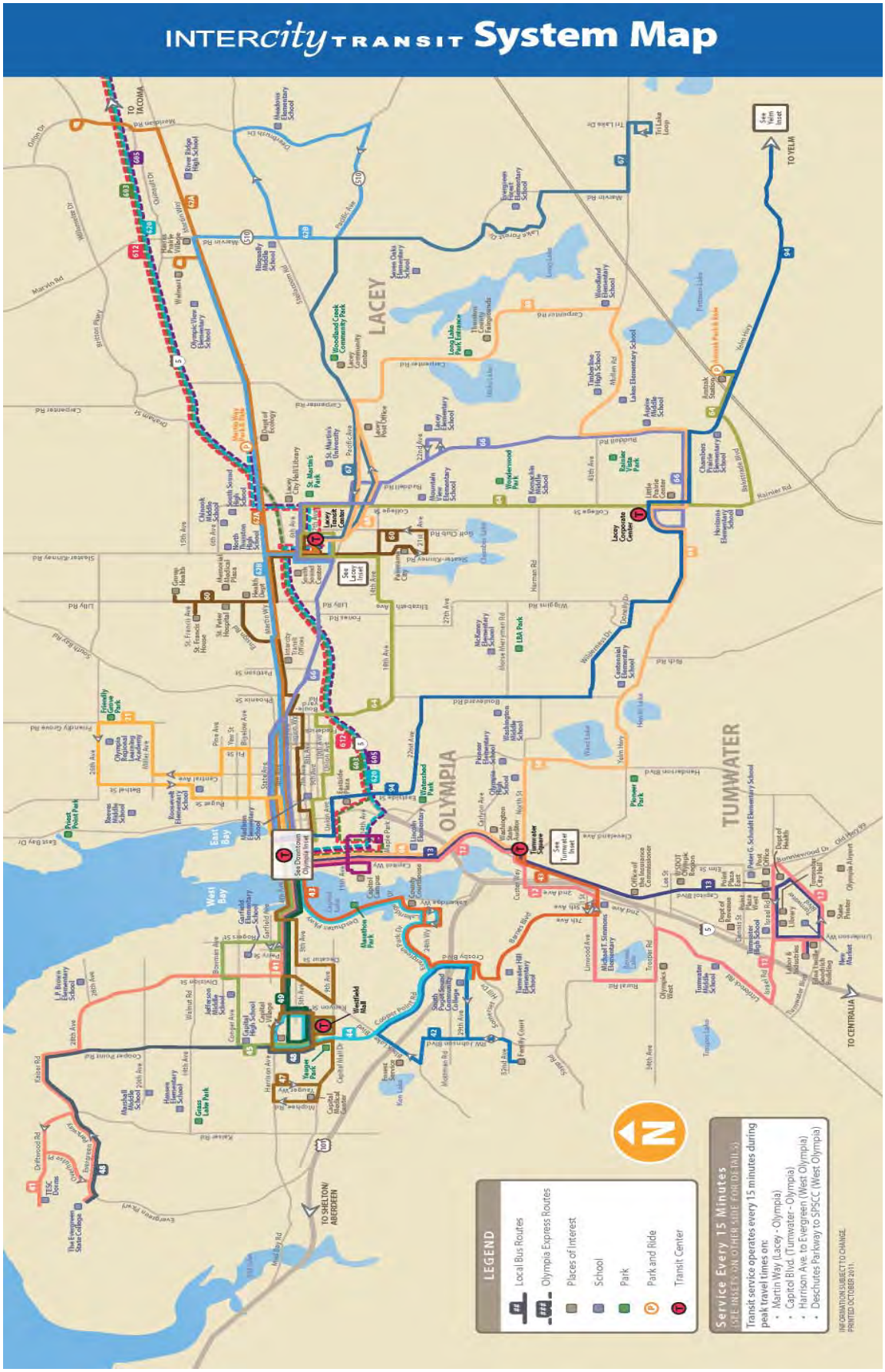

Exhibit D-11: Smart Corridors Region Intercity Transit Routes Map

5.2. Description of Capitol Corridor Transit Routes

Nine Intercity Transit bus routes operate along the two Smart Corridors including nine local transit routes, one express, and one downtown shuttle. Three of the local routes travel the length of the two Smart Corridors: Route 13 on the Capitol Way Corridor and routes 62A and 62B on the Martin Way corridor. These routes are referred to as "corridor routes" for the purposes of this analysis. They are also the highest ridership routes in the study, carrying over half of the total daily riders on the nine routes.

	ROUTE NUMBER				
	13	12	68	603	101
Route Length(mi.)	5.5	8.1	14.5	32.9	2.3
Smart Corridor Used by Route	Capitol	Capitol	Capitol	Capitol	Capitol
Route Length on Smart Corridor (mi.)	4.4	2.0	2	0.8	0.7
Average Speed (mph)	11.2	13.9	15.8	24.9	7.6
Weekday Boarding Riders	1,430	339	781	708	428
Weekday Service Hours	52.35	25.51	38.73	42.38	37.25
Productivity (Boarding Riders Per Revenue Hour)	27	13	20	17	11

Exhibit D-12: Capitol Corridor – Intercity Transit Routes and Performance

- **Route 13** – This route operates with frequent 15 minute headways during peak periods from the State Office Complex in Tumwater to downtown Olympia via Capitol Boulevard, Tumwater Square, and Capitol Way. It forms the primary transit link between Olympia and Tumwater.
- **Route 12** – This route operates every hour on weekdays providing local service on Capitol Way from the Olympia transit center to Tumwater Square and then via Custer Way, 2nd Avenue, Linwood Avenue, Rural Road, Trosper Road, Littlerock Road and Israel Road to Labor and Industries. Route 12 provides local transit service to the portion of Tumwater west of I-5.
- **Route 68** - This route operates every hour on weekdays providing local service on Capitol Way from the Olympia Transit Center to Tumwater Square and then via North Street, Henderson Boulevard, Yelm Way, Ruddell Road, Mullen Road, Carpenter Road, and Pacific Avenue to the Lacey Transit Center. Route 68 serves the southeastern section of Tumwater and central Lacey including the Lacey Corporate Center and Long Lake Park.
- **Route 603** – This route is an express from downtown Tacoma to downtown Olympia via I-5 with stops at the Lacey Transit Center, Martin Way Park and Ride, SR512 Park and Ride, Tacoma Dome Station, and downtown Tacoma. This route provides connections to the Sounder, Sound Transit and Pierce Transit buses to destinations throughout the greater Puget Sound area.
- **Route 101 (Dash)** – This route operates every 12 minutes on weekdays from the Olympia Farmer's Market to the Washington Department of Transportation building via Capitol Way, 14th Avenue, Cherry Lane, 11th Avenue, and Jefferson Street. It provides frequent shuttle service through downtown Olympia connecting commercial areas and state offices.

These routes along the Capitol Way / Boulevard are illustrated in *Exhibit D-13* :

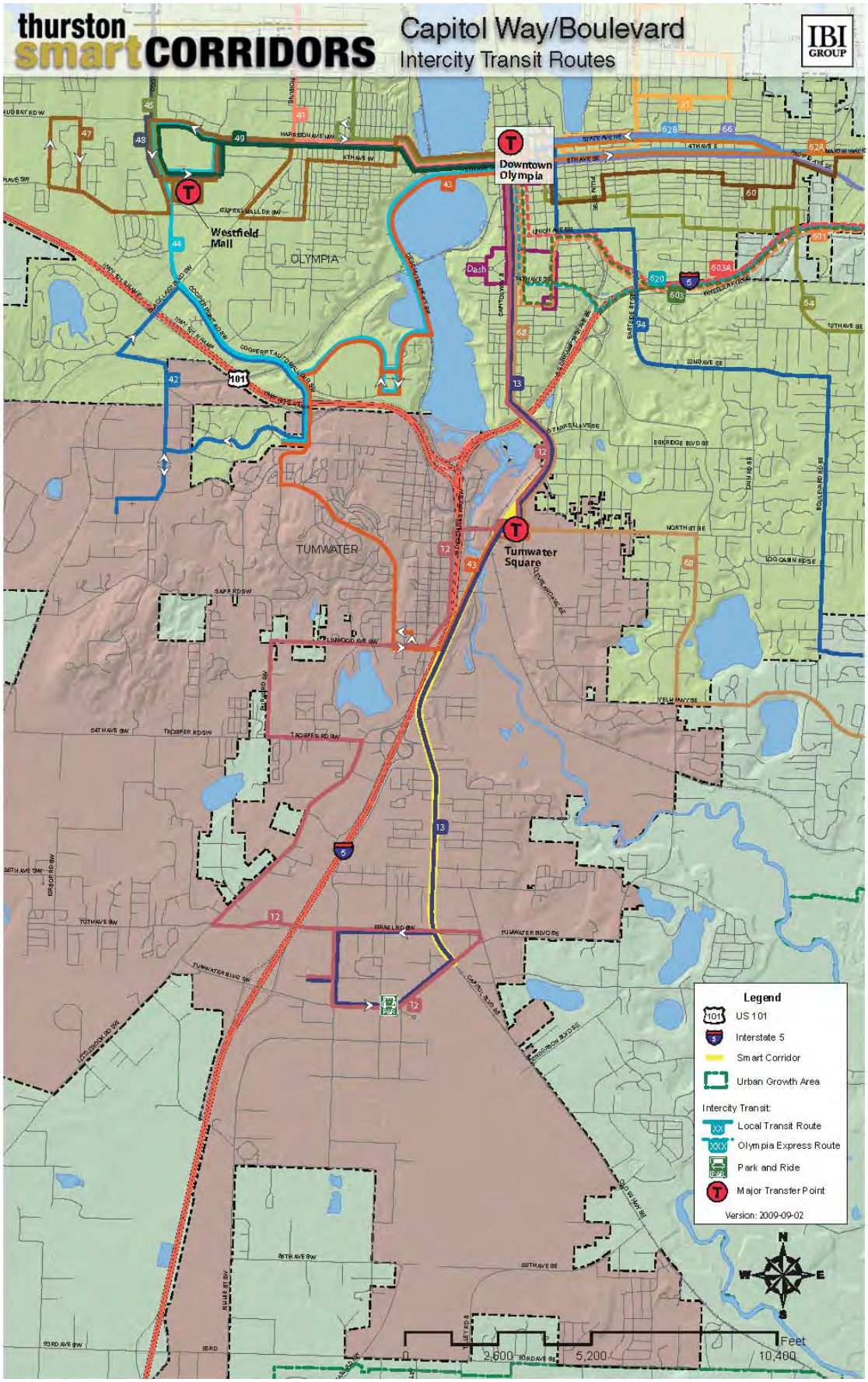

Exhibit D-13: Capitol Corridor Intercity Transit Routes

5.3. Description of Martin Way Corridor Routes

Like the Capitol Corridor, Martin Way is an important corridor for several transit routes between Olympia and Lacey and beyond, as described below.

	ROUTE NUMBER			
	62A	62B	21	66
Route Length (mi.)	10.0	10.4	3.1	9.4
Smart Corridor Used by Route	Martin	Martin	Martin	Martin
Route Length on Smart Corridor (mi.)	6.6	6.6	0.6	1.3
Average Speed (mph)	12.2	12.7	12.7	12.9
Weekday Boarding Riders	1,362	1,387	310	1,282
Weekday Service Hours	43.3	46.75	10.25	46.67
Productivity (Boarding Riders Per Revenue Hour)	31	30	30	27

Exhibit D-14: Martin Corridor – Intercity Transit Routes and Performance

- **Route 62A** – This route operates every 30 minutes during peak periods from Meridian Road in Lacey to downtown Olympia via Martin Way, the Lacey Walmart, and the Lacey Transit Center. Combined with route 62B it provides frequent service along Martin Way and forms the key transit link between Olympia and Lacey.
- **Route 62B** – This route operates every 30 minutes from the Meadows in Lacey to downtown Olympia via Martin Way and the Lacey Transit Center. Combined with route 62A it provides service every 15 minutes in the Martin Way corridor from Marvin Road to the Olympia transit center.
- **Route 21** – This route operates every hour from the Olympia Transit Center to Olympia Regional Learning Academy via 4th and State Avenues, Bigelow Avenue, Central Avenue, Miller Avenue, and Friendly Grove Road, returning via Bethel and Puget Street. It provides local transit service to the northern neighborhoods of Olympia.
- **Route 66** – This route operates every 30 minutes from the Lacey Corporate Center to downtown Olympia via Ruddell Road, Pacific Avenue, the Lacey Transit Center and 4th and State Avenues. It has the highest ridership of any of the local routes.

These routes along the Martin Way / 4th Avenue / State Avenue corridor are illustrated in *Exhibit D-15* .

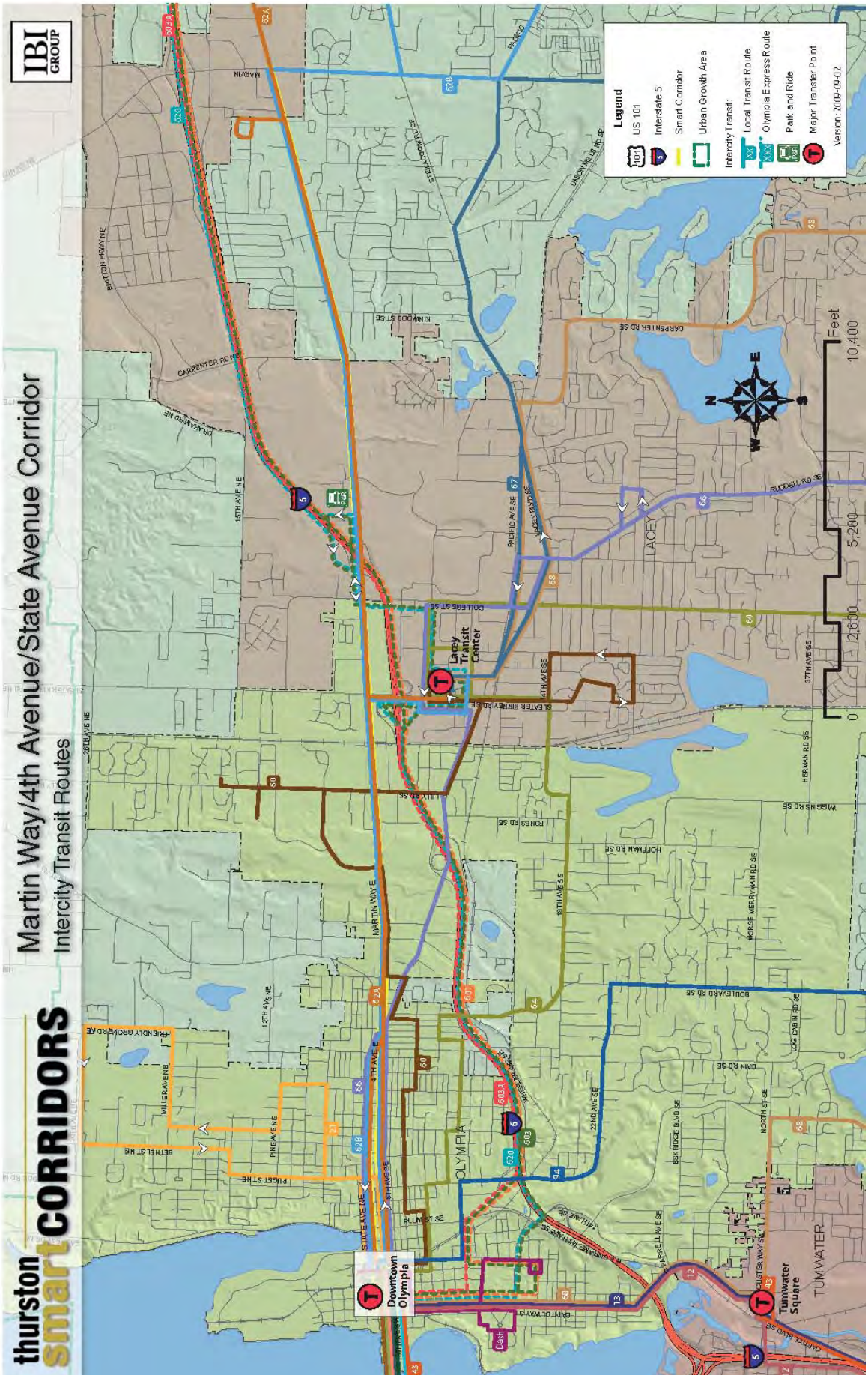

Exhibit D-15: Martin Way Intercity Transit Routes

5.4. Express Routes to Pierce County

Intercity Transit provides service transit from the greater Olympia area to Pierce County (Tacoma and Lakewood), where connecting service to Seattle is available (Routes 601, 603, 603(A), and 620).

Express services to Pierce County use I-5 as well as portions of both the Martin and Capitol Smart Corridors. During freeway incidents, express services sometime divert of off the I-5 freeway onto the parallel Smart Corridors.

5.5. Ridership Patterns

Intercity Transit provided ridership by route and stop for the nine routes in the Smart Corridors. This information was analyzed to identify the most heavily traveled routes and stops. Information covers the period of September, October, and November of 2008, which was Intercity Transit's highest 3-month ridership period, and therefore the highest stress test for schedule adherence. Ridership data was derived from Automatic Passenger Counter (APC) data collection onboard Intercity Transit vehicles.

5.5.1. Routes

Ridership in the two study corridors is concentrated on routes 13, 62A and 62B. These routes provide high frequency service to important destinations and to transit transfer centers. High frequency and more direct service is more competitive with the auto and therefore attracts higher levels of ridership. *Exhibit D-16* shows the average weekday boardings on the nine routes in the study corridors and the percentage of the total that each contributes.

ROUTE	CORRIDOR	WEEKDAY BOARDINGS (2009)	PERCENT OF TOTAL
12	Capitol Way	339	4%
13	Capitol Way / Boulevard	1,430	18%
68	Capitol Way	781	10%
101 (Dash)	Capitol Way	428	5%
603	Capitol Way	708	9%
	Total Capitol Way	**3,686**	**46%**
21	4th / State	310	4%
62A	4th / State / Martin	1,362	17%
62B	4th / State / Martin	1,387	17%
66	4th / State / Martin	1,282	16%
	Total Martin Way	**4,341**	**54%**
	Total Smart Corridors	**8,027**	**100%**

Exhibit D-16: Average Weekday Boardings by Route

5.5.2. Key Passenger Stops

Ridership is concentrated at a number of high volume stops that serve major activity centers or primary transfer points, as shown in the following tables.

STOP	DAILY BOARDINGS AND ALIGHTINGS (2009)
Olympia Farmer's Market	168
Olympia Transit Center	8,028 (all routes)
Capitol and State	294
Legion Way	131
Capitol and 7th	137
11th Avenue	293
Tumwater Square	597
Lee	179
Dennis	138

Exhibit D-17: Major Stops on Capitol Way Smart Corridor

STOP	DAILY BOARDINGS AND ALIGHTINGS (2009)
Olympia Transit Center	8,028 (all routes)
Pear	125
Eastside	180
Fairview	134
Pattison	155
Lilly	225
7th and Fred Meyer Center	193 (all routes)
Lacey Transit Center	2,521 (all routes)
Marvin	121

Exhibit D-18: Major Stops on Martin Way Smart Corridor

Ridership in the two study corridors is concentrated both in terms of routes and stops. This is not unusual since major activity centers generally concentrate travel demand in their area for all modes. Similarly, certain corridors that connect major activity centers tend to become the most heavily traveled routes in any urban area. This effect is more pronounced for transit because the added frequency of service necessary to accommodate demand serves to further stimulate usage.

5.6. Travel Time and On-Time Performance

An analysis of the travel time data provided by Intercity Transit's CAD/AVL system and a review of travel times presented in public schedules was completed. Travel time is a function of route length, dwell time, which is affected by ridership volume, fare collection, times transfers, schedule variability and recovery time, and average speed.

5.6.1. Scheduled Travel Time

Overall average scheduled travel speeds on corridor and local routes is consistently between 11 and 13 miles per hour (see table below). The one exception is Route 68 (average speed 15.8) which travels through more rural areas than the other routes where traffic congestion has less of an impact on travel time. Express Route 603 had a significantly higher average speed, as would be expected of a route that travels primarily on expressways, and the Dash shuttle route had a lower average speed due to its operations primarily on more congested downtown streets.

ROUTE	SMART CORRIDOR	ROUTE TYPE	AVERAGE SPEED (MPH)
12	Capitol Way	Local	13.9
13	Capitol Way / Boulevard	Corridor	11.2
68	Capitol Way	Local	15.8
Dash	Capitol Way	Shuttle	7.6
603	Capitol Way	Express	24.9
21	4th / State	Local	12.7
62A	4th / State / Martin	Corridor	12.2
62B	4th / State / Martin	Corridor	12.7
66	4th / State / Martin	Local	15.8

Exhibit D-19: Average Speed by Route

5.6.2. Recorded Travel Time

Recorded travel time was analyzed for the three key smart corridor routes: 13, 62A and 62B. A table of average running times between major timepoints was created for each route, showing average travel times as compared to scheduled times for each weekday trip between every pair of consecutive timepoints.

Recorded travel times differed significantly from scheduled travel times, as shown in the summary tables below. In almost every case the recorded travel time was less than the scheduled travel time—in some cases significantly so. In the case of the inbound travel time between the Martin Way and Carpenter stop and the Lacey Transit Center, the unusually large discrepancy between scheduled and running time is likely due to scheduled layover at the transit center.

	LEAVES OLYMPIA TRANSIT CENTER / BAY D	CAPITOL WAY & 11TH	TUMWATER SQUARE	CAPITOL & W. LEE	LABOR & INDUSTRIES	CAPITOL & E. LEE	TUMWATER SQUARE	CAPITOL WAY & 11TH	ARRIVES OLYMPIA TRANSIT CENTER	TOTAL
	1	2	3	4	5	4	3	2	1	
Run time from previous column										
Scheduled		5	5	5	10	7	9	4	8	53
Recorded		5.25	4.5	5.75	5.75	8.5	5.25	5	4.25	44.25
Difference		0.25	-0.5	0.75	-4.25	1.5	-3.75	1	-3.75	-8.75

Exhibit D-20: Route 13 Scheduled and Observed Run Times

LEAVES OLYMPIA TRANSIT CENTER / BAY H	MARTIN WAY & PATTISON	LACEY TRANSIT CENTER / BAY H	MARTIN WAY & CARPENTER	MARTIN & MARVIN (KEY BANK)	MARTIN & MERIDIAN	MARTIN & MARVIN (RITE-AID)	MARTIN WAY & CARPENTER	LACEY TRANSIT CENTER / BAY C	MARTIN WAY & PATTISON	ARRIVES OLYMPIA TRANSIT CENTER	TOTAL
Run time from previous column											
Scheduled	8	12	9	8	10	3	7	20	8	12	97
Observed	8.75	8	9.25	9	5.75	3.5	5.75	9.5	8.5	7.25	75.25
Difference	0.75	-4	0.25	1	-4.25	0.5	-1.25	-10.5	0.5	-4.75	-21.75

Exhibit D-21: Route 62A Scheduled and Observed Run Times

LEAVES OLYMPIA TRANSIT CENTER/ BAY H	MARTIN WAY & PATTISON	LACEY TRANSIT CENTER / BAY H	MARTIN WAY & CARPENTER	MARVIN & MARTIN (GROCERY OUTLET)	PACIFIC & ROCKCRESS	MARTIN & MARVIN (RITE-AID)	MARTIN WAY & CARPENTER	LACEY TRANSIT CENTER / BAY C	MARTIN WAY & PATTISON	ARRIVES OLYMPIA TRANSIT CENTER	TOTAL
Run time from previous column											
Scheduled	8	12	9	6	14	7	4	20	8	12	100
Observed	8.75	8	9.25	5	9.5	6.75	5.75	9.5	8.5	7.25	78.25
Difference	0.75	-4	0.25	-1	-4.5	-0.25	1.75	-10.5	0.5	-4.75	-21.75

Exhibit D-22: Route 62B Scheduled and Observed Run Times

5.6.3. On-Time Performance

An analysis of the on-time performance data provided by Intercity Transit's APC system between September and December of 2008 was completed for Routes 13, 62A and 62B, which travel the complete length of the two study corridors. The average deviation from scheduled end-of-trip arrival times over this period was reviewed for every weekday trip. Standard transit practice considers vehicles that arrive at the end of their trip that are more than one minute early or five minutes late to be not "on-time" for performance measuring purposes.

Of the 216 trips reviewed, only 49 were on average on-time by this definition. No trips ran late on average. In general, out bound trips and trips later in the day tended to be more punctual than early trips or inbound trips.

The main reason for this result is that Intercity Transit includes extra time in their schedules to account for inconsistent running times due to traffic congestion. This extra time is added to the schedule just before major transfer points like the Lacey Transit Center and Olympia Transit Center, giving each trip a bit of extra time so that it will arrive on time even if it encounters congestion. Therefore, if the bus is not delayed, it will arrive early according to the schedule. This system builds a level of reliability into arrivals at major stops, especially where there are a number of connecting routes and in spite of showing many trips as arriving early, does not automatically represent a problem with service delivery.

Adding additional running time to schedules to avoid late arrives does have a cost associated with it because it adds to the amount of time that buses have to remain on the road and increases the number of buses needed to operate a route. A major consideration of this study will be to determine whether ITS features such as TSP can yield a similar reliability result in a more efficient way (i.e., by requiring less time buffers in transit trips).

5.6.4. Running time

Intercity Transit completed an analysis of weekday running times on routes 13, 62A and 62B by time of day. In this case running time includes only travel time and not layover or recovery time at terminals and major stops. This provides a picture of how much of the extra time added to schedules for reliability is actually needed and when and where it is being used. The analysis compared 2005 running times with 2008 running times to provide a perspective on how changing traffic congestion is affecting transit travel.

Findings include:

- Running times along Martin Way vary considerably by time of day generally continuously increasing from morning through the afternoon peak hour. Running times at 4 pm are typically 15% to 25% higher than at 7 am increasing from around 32 minutes to 42-59 minutes..
- Running times along Capitol Way are more consistent through the day except for a drop of about 10% during the late morning.
- Outbound running times are 2 to 4 minutes longer than inbound running time on Martin Way and inbound running times are longer by about 2 to 4 minutes on Capitol Way. The reasons for this are unknown.
- Running times have increased on Martin Way by 5% to 15% between 2005 and 2008. The increase is greater outbound than inbound. This is likely a function of increasing traffic congestion on Martin Way and intersecting roadways.
- Running times have not changed significantly on Capitol Way between 2005 and 2006.

5.6.5. Sources of Delay

Intercity Transit discussed major sources and locations of delay with bus operators. They identified a number "hot spots" for delays in the study corridors including downtown Olympia, Lacey Transit Center, and Tumwater Square. Many of the locations include left turns where no protected left turn signal phase is provided. This becomes a significant issue when buses make a series of left turns to access a transit center. Also included are locations where bus routes travel past entrances and exits from I-5.

Locations identified with significant delay included along Capitol Way at State, and 4th, State Street at Franklin,

the approaches to the Lacey transit center on Sleater Kinney and 6th, Martin Way where it crosses I-5 in Lacey, Capitol Boulevard at Trosper Road near the I-5 entrance and Custer Way near Tumwater Square.

The run time and on-time performance analysis indicates that delay is not a significant issue in either of the study corridors. Some issues may have been missed since the data analyzed was average data over time, so some days with delays may have been diluted by many days when service ran early. Still, such significant delay would not be consistent with recurring traffic congestion, but rather specific incidents.

5.6.6. Performance Metrics

A solid program for monitoring the success of the Smart Corridor programs will rely on the provision of reliable data on transit operations. Intercity Transit implemented a new CAD/AVL system with automated passenger counters that provides a wealth of data on resource allocation in terms of vehicles miles and hours, travel time, on-time performance, and passenger boardings and alightings.

The following metrics could be used to evaluate the Smart Corridor program's effects on transit operations and performance:

- **On-time Performance** – The ability for transit operations to operate as close to schedule as possible provides a more convenient and dependable service for the public, allowing transit riders to plan their activities around transit and thereby increasing ridership.
- **Consistency of Running Times** – Related to on time performance is consistency of running times between timepoints, which allows more closely defined schedules and resource allocation that does not require as much "play" to remain reliable.
- **Average Speed** – Faster schedules are more attractive to the riding public and less expensive to operate.
- **Productivity of Operations** in terms of boarding riders per revenue hour – Ideally the program would increase ridership and streamline operations in a way that would reduce the requirements for service hours, leading to improvements on both sides of the productivity equation.
- **Auto versus Transit Travel Times** – Tracking the relative change in the attractiveness of the auto and transit modes in the two corridors would provide insights into the ability for transit to win a larger share of the total travel market. This mode share would be reflected in auto, transit travel times. The larger the transit mode share, the better the performance of both the transit and auto system performance since congestion is reduced for both. Ideally, transit would be able to reduce its running time down to auto drive time plus an efficient level of dwell time.

6. Summary – Corridor Operations Issues

6.1. Operational Issues Identified

The following baseline conditions of operational problems were identified upon review of previous documentation from the region and during the interviews with the project stakeholders:

MAJOR OPERATIONAL ISSUE	DESCRIPTION
Traffic / Roadway Operational Issues	
Signalized Congestion	Recurring signalized intersection congestion at key locations (i.e. Martin Way / College area; Trosper / I-5 area; downtown Olympia).
Lack of Incident Management, Signal Coordination and Freeway / Arterial Coordination	I-5 incidents, and to a limited extent diversion routes from US 101, cause non-recurring congestion on the Smart Corridors at varying levels of severity due to weather, incidents, and construction activity. Freeway traffic diverts to surface streets, even without information messaging or formal detours, to avoid or bypass congestion caused by the incidents on the freeway. Emergency vehicle preemption activation is a leading cause of non-recurring congestion within the corridors; however, it provides a critical function in reducing emergency response times across the region. Existing WSDOT route diversion plans rely on manual signage and intervention of traffic control personnel. Experience with implementation and management of saturated arterial detour routes has been mixed. There is limited operational coordination with WSDOT TMC, which has primarily focused on Pierce County operations. Local agencies have not established communication agreements with the WSDOT TMC for notification of incident, sharing information and coordinating activities. However, ITS deployment and interest in more active freeway/arterial management are both increasing.
Technology Limitations – Traffic Signal Control Systems	Existing signal controllers are becoming functionally obsolete (i.e. 170s and Traconex) making them more difficult to maintain and limiting more advanced operations capabilities such as transit signal priority. Real-time signal timing adjustments are limited during periods of congestion. Existing central systems are limited as are the controllers; however, more critically, no operations personnel are assigned to actively monitor traffic conditions and make adjustments in real-time conditions.
Transit Operational Issues	
Growth and Increased Variability in Running / Travel Times	Transit operations are affected by operation within congested corridors, and have experienced increased growth and variability in peak period travel times within the corridors. To account for this variability, Intercity Transit has provided extra time in their schedules that in turn, increase the numbers of buses needed to operate a route.

Exhibit D-23: Baseline Conditions of Operational Problems

6.2. Areas of Opportunity

Based on the assessment of baseline conditions described above, the following needs could be addressed to mitigate the arterial operational issues encountered in the region:

- **Reducing Signal Operational Inefficiencies** – Upgrades and improvements to the signal system field and central system equipment will permit more advanced operations that can increase responsiveness to high demand traffic conditions
- **Reducing Transit Operational Inefficiencies** – Improvements to make the bus transit mode competitive with the automobile mode can help increase transit use and reduce overall roadway vehicle demand.
- **Mitigating Emergency Vehicle Pre-emption Impacts** – While ESP is valued across the region, it is a source of congestion and operational inefficiency that could be reduced through more robust signal control.
- **Greater Resource Sharing** – Most of the operating agencies in Thurston County have limited staff, resources to provide optimal operating and maintenance services; thus, greater resource sharing could help improve these services.
- **Improve Incident Management Coordination / Integrated Corridor Management** – Greater information sharing and coordinating activities during incidents, with significant impacts on parallel arterial / freeway corridors, can help mitigate the adverse impacts of the incidents and optimize the performance of the network across jurisdictional boundaries and roadway classifications.
- **Greater Information Sharing** – Information sharing amongst regional agencies can be used to better inform each operating agency as well as the traveling public about trends, performance of the traffic / transit operations in the region.

Exhibit D-24 shows how the above needs are derived from the operational issues / baseline conditions (described earlier):

BASELINE CONDITION(S)	OPERATIONAL NEED(S)
Recurring Signalized Congestion at key locations Technology limitations with existing signal controls and with real-time signal adjustments Limited traffic signal management in supporting WSDOT diversion plans	• Reducing Signal Operational Inefficiencies
Adverse impacts of freeway (I-5, US 101) incidents on Smart Corridor operations	• Improved Incident Management • Coordination / Integrated Corridor Management
Increased growth and variability in peak period travel / running times	• Reducing Transit Operational Inefficiencies
Non-Recurring Congestion that is caused by emergency vehicle pre-emption	• Mitigate Emergency Vehicle Pre-Emption Impacts
Limited operational coordination with WSDOT	• Greater Resource and Information Sharing

Exhibit D-24: Needs Derived from Operational Issues

The next document, High Level System Functional Requirements, outlines near term and future requirements for candidate technology systems to help address the operational issues and needs identified above.

IBI GROUP

TAB E:

CONCEPT OF OPERATIONS

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Concepts of Operations

1. Introduction

This chapter presents the Concept of Operations for the Thurston County Smart Corridors project, developed as part of the Systems Engineering process.

The Concept of Operations describes:

- How participating Smart Corridors agencies will work together to operate the proposed traffic signal and transit priority systems at the regional level;
- Key business processes and end user outcomes supported by the System, as a basis for specification and design of system components; and
- Individual agency roles and responsibilities in system operations and maintenance.

2. Overview of Agency Roles and Responsibilities

The agencies of the Regional Traffic Operations Group (RTOG), stakeholders involved in the planning / management of the Smart Corridors project, are listed in the table below. Besides each agency is a portions of its roles and responsibilities in operating and maintaining the subsystem associated with the four near term technology strategies (Interagency Signal Coordination, Incident and Event Management, Transit Signal Priority, and Regional Data Analysis and Performance Measurement).

CITIES OF OLYMPIA, LACEY, AND TUMWATER	• Own, operate and maintain signal system infrastructure • Implement Incident Management Plans • Own TSP Infrastructure, Operate TSP System, Maintain TSP System • Provide Smart Corridors Data to TRPC for regional data analysis and performance measurement
INTERCITY TRANSIT (IT)	• Facilitate coordination and agreements among stakeholders • Own TSP Infrastructure, Operate TSP System, Maintain TSP System, Monitor TSP Performance • Provide Smart Corridors Data to TRPC for regional data analysis and performance measurement
THURSTON COUNTY	• Facilitate coordination and agreements among stakeholders • Monitor TSP Performance • Retrieve / Maintain / Analyze Regional Smart Corridors Data
THURSTON REGIONAL PLANNING COUNCIL (TRPC)	• Facilitate coordination and agreements among stakeholders • Monitor TSP Performance • Retrieve / Maintain / Analyze Regional Smart Corridors Data
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)	• Own and operate signal system infrastructure • Implement Incident Management Plans • Own TSP Infrastructure and Monitor TSP Performance • Provide Smart Corridors Data to TRPC for regional data analysis and performance measurement

Exhibit E-1: Agencies of RTOG

SMART CORRIDORS STRATEGY	1. Regional Traffic Signal Operations
Description of System Functions	This Operational Concept describes coordination of traffic signal systems across multiple jurisdictions. Such coordination supports the dynamic adjustment of signal timing plans in response to changing conditions. Implementing this concept requires the sharing of traffic information, infrastructure, and control among operating agencies to enable greater inter-jurisdictional traffic management in response to variable traffic conditions. Such coordination would be facilitated by interagency agreements. Regional Traffic Signal Operations also accounts for ongoing operations and maintenance of traffic signal infrastructure, including joint operating agreements and cooperation in maintenance and training.
Key Operational Objectives	• **Reduce Signal Operational Inefficiencies** – Upgrades and improvements to the signal system field and central system equipment will permit more advanced operations and coordination that can increase responsiveness to high demand traffic conditions. • **Mitigate Emergency Vehicle Pre-emption Impacts** – Reduce residual impacts of emergency vehicle signal pre-emption on traffic flow through more robust signal control, particularly during peak periods. • **Share Resources** - Most of the operating agencies in Thurston County have limited staff resources; sharing these resources will help optimize traffic operations and maintenance services.

Exhibit E-2: Regional Traffic Signal Operations Strategy

REGIONAL SIGNAL OPERATIONS
Agency Roles and Responsibilities

Smart Corridors Participating Agency	Related Roles and Responsibilities	Own Signal Infrastructure	Own Signal Infrastructure Operate Signal System	Operate Signal System Maintain Signal System
Cities of Olympia, Lacey, and Tumwater	• Own Signal Infrastructure along Smart Corridors • Operate and Maintain Signal Infrastructure, including traffic signals, detection and surveillance within each agency's jurisdiction • Develop, Review, and Implement coordinated Signal Timing Plans and arterial traffic management strategies • Share signal timing plans with other agencies for inter-jurisdictional signal coordination • Construction Management (when applicable) • Real-Time Traffic Monitoring / Network Surveillance • Notify nearby jurisdictions when service interruptions occur that could affect system operations • Cooperate with all participating agencies to develop traffic operations strategies to efficiently move traffic through the corridor • Provide mutual technical support and pooling of spare parts and materials in support of ongoing maintenance and emergency repairs.	✓	✓	✓
Thurston County	• Own Signal Infrastructure along Smart Corridor • Develop and Implement Signal Timing Plans in coordination with City of Lacey (operating agency) • Share signal timing plans with other agencies for inter-jurisdictional signal coordination	✓		
Thurston Regional Planning Council (TRPC)	• Facilitate regional coordination and development of memoranda of understanding for Regional Signal Operations	Facilities and Agreements		

REGIONAL SIGNAL OPERATIONS **Agency Roles and Responsibilities** - *continued*				
Smart Corridors Participating Agency	**Related Roles and Responsibilities**	**Own Signal Infrastructure**	**Own Signal Infrastructure Operate Signal System**	**Operate Signal System Maintain Signal System**
Washington State Department of Transportation (WSDOT)	• Own Signal Infrastructure along Smart Corridors • Develop and Implement Signal Timing Plans in coordination with Olympia, City of Tumwater and City of Lacey • Real-Time Traffic Monitoring / Network Surveillance • Share signal timing plans with other agencies to enable coordination between freeway / highway operations and traffic signal control on municipal roadways	✓	✓	

Exhibit E-3: Regional Signal Operations Agency Roles and Responsibilities

SMART CORRIDORS STRATEGY	2. Incident and Event Management
Description of System Functions	This Operational Concept involves the inter-jurisdictional management of planned events and unexpected incidents that necessitates a coordinated response with partner agencies in the region. It also includes detection abilities through roadside surveillance technologies and regional coordination with other traffic management centers. The link between transportation and emergency management agencies is vital to incident and event management, and is supported through pre-defined operational management plans, systems integration, and training exercises. This is made possible through data and information sharing that provides 'situational awareness' to emergency responders and aids in dispatch of the appropriate response tools. In the Thurston Region, this may include sharing of traffic surveillance images and traffic flow data with emergency response agencies in the future. Incident and Event Management in the Thurston Region may include multi-jurisdictional coordination to implement and mitigate the impacts of WSDOT freeway diversion routes that have been developed for the region. Transportation agencies can support the emergency response effort by managing regional traffic response through traveler information, diversions / detours, or altered traffic signal timing for example. These strategies in turn are supported by pre-planned incident response plans, scenarios, and training that builds the tactical working relationships among agencies.
Key Operational Objectives	• **Improve Level of Incident Management Coordination / Integrated Corridor Management** – Information sharing and coordinating activities during incidents / events with major impacts on parallel arterial / freeway corridors can help mitigate adverse impacts and optimize the performance of the network across jurisdictional boundaries and roadway classifications.

Exhibit E-4: Incident and Event Management Strategy

INCIDENT AND EVENT MANAGEMENT Agency Roles and Responsibilities			
Smart Corridors Participating Agency	**Related Roles and Responsibilities**	**Implement Incident Management Plans**	**Provide Traveler Information (Future)**
Cities of Olympia, Lacey, and Tumwater	• Implement inter-jurisdictional Incident / Event Traffic Timing Plans • Participate in implementation of freeway detour plans through management of diversion routes and spill-over traffic • Provide Traffic Traveler Information to public and transit agencies (FUTURE) • Implement and manage WSDOT Freeway Diversion Routes and spill over traffic (FUTURE)	✓	✓
Intercity Transit (IT)	• Coordinate with traffic agencies on incident related disruptions with transit service • Provide traveler information to transit riders affected by incident	✓	✓
Thurston Regional Planning Council (TRPC)	• Facilitate regional coordination and development of memoranda of understanding for Incident and Event Management	Facilities and Agreements	
Washington State Department of Transportation (WSDOT)	• Implement inter-jurisdictional Incident / Event Traffic Timing Plans • Provide Traffic Traveler Information • Coordinate with other WSDOT regions and state Emergency Operations Center for large scale incident response • Implement WSDOT Freeway Diversion Routes in concert with local agencies (FUTURE)	✓	✓

Exhibit E-5: Incident and Event Management Agency Roles and Responsibilities

SMART CORRIDORS STRATEGY	3. Transit Signal Priority (TSP)
Description of System Functions	This Operational Concept involves utilizing sensors to detect transit vehicles approaching intersections and altering signal timing based on pre-determined criteria to improve transit performance. The primary goal of transit signal priority is to improve on-time performance of the transit system without degrading overall performance of the traffic network. TSP in the Thurston Region involves coordination between Intercity Transit onboard vehicle equipment (which includes schedule adherence data) and roadside traffic control equipment operated by local traffic agencies. Therefore, delivery of TSP required ongoing cooperation between Intercity Transit and local traffic agencies to design, implement, monitor, and maintain TSP infrastructure and operating parameters.
Key Operational Objectives	• **Reduce Transit Operational Inefficiencies** – TSP facilitates improvements such as reductions in travel time and intersection delay that in turn, make the bus transit mode more competitive with the automobile mode. This enhanced level of service can help increase transit ridership and thus, reduce overall roadway vehicle demand. • **Increase Corridor Person Throughput** – More effective transit provides increased person-capacity through the constrained intersections and arterials along the Smart Corridors.

Exhibit E-6: Transit Signal Priority Strategy

TRANSIT SIGNAL PRIORITY (TSP) Agency Roles and Responsibilities					
Smart Corridors Participating Agency	**Related Roles and Responsibilities**	**Own TSP Infrastructure**	**Operate TSP**	**Maintain TSP System**	**Monitor TSP Performance**
Cities of Olympia, Lacey, and Tumwater	• Develop, Review, and Implement TSP Routines • Operate / Maintain Roadside TSP Infrastructure • Share data to support regional TSP operations • Monitor and Evaluate traffic system performance under TSP • Log / Report TSP Events and Errors	✓	✓	✓	
Intercity Transit	• Develop, Review, and Implement TSP Routines • Operate / Maintain Central / Onboard TSP Infrastructure • Coordinate with local traffic signal operators to operate TSP • Share data to support regional TSP operations • Monitor and Evaluate Transit System / TSP Performance	✓	✓	✓	✓
Thurston County	• Develop, Review, and Implement TSP Routines in cooperation with City of Lacey • Coordinate with operating agencies on TSP performance at WSDOT intersections operated by the Cities of Tumwater and Lacey	✓			✓
Thurston Regional Planning Council (TRPC)	• Monitor Transit System / TSP Performance				✓
Washington State Department of Transportation (WSDOT)	• Develop, Review, and Implement TSP Routines in cooperation with the Cities of Tumwater and Lacey • Coordinate with operating agencies on TSP performance at WSDOT intersections operated by the Cities of Tumwater and Lacey	✓			✓

Exhibit E-7: Transit Signal Priority Agency Roles and Responsibilities

SMART CORRIDORS STRATEGY	4. Regional Data Analysis and Performance Measurement
Description of System Functions	Smart Corridors operational data will be archived Thurston Regional Planning Council in a Regional Data Archive that will be accessible for performance measurement, planning, incident / event debriefing, and other uses. This Operational Concept involves the archiving of data by multiple agencies into a central repository, which provides general query and report access. Based on infrastructure capabilities, this may include traffic count data generated by signal loop detectors; signal performance and delay information, and transit performance information. Potential users of the archive include "transportation planners, operators, and maintainers." The objective of the Regional Data Archive is to leverage the large quantity of data generated by Smart Corridors systems to effectively plan and monitor the transportation system, capture the benefits of the Smart Corridors investment, and demonstrate the impacts of operational / ITS investments
Key Operational Objectives	• **Improve Quality of, and Access to, Regional Transportation System Data** – Data sharing among regional agencies allows agencies to better understand and evaluate regional planning need (e.g., through the Congestion Management process) and to plan for new investments. • **Support Regional Transportation System Performance Measurement** – Use operational data to evaluate the performance of the multimodal transportation network, particularly the efficacy of prior operations / ITS investments

Exhibit E-8: Regional Data Analysis and Performance Measurement Strategy

REGIONAL DATA ANALYSIS AND PERFORMANCE MEASUREMENT
Agency Roles and Responsibilities

Smart Corridors Participating Agency	Related Roles and Responsibilities	Own TSP Infrastructure	Operate TSP	Maintain TSP System
Cities of Olympia, Lacey, and Tumwater	• Collect and supply Arterial Traffic Signal performance data to Regional Data Archive for agency-operated signals	✓		✓
Intercity Transit (IT)	• Provide transit system operations data • Share data with traffic agencies that maintain / operate roadside TSP infrastructure	✓		✓
Thurston County	• Collect and supply Arterial Traffic Signal performance data to Regional Data Archive (through operating City of Lacey)	✓		✓
Thurston Regional Planning Council (TRPC)	• Develop and manage the regional data archive • Facilitate Interagency Agreements and coordination • Conduct regional planning and performance measurement evaluations using archive data		✓	✓
WSDOT	• Collect and supply Arterial Traffic Signal performance data to Regional Data Archive (through operating Cities of Lacey and Tumwater)	✓		✓

Exhibit E-9: Regional Data Analysis and Performance Measurement Agency Roles and Responsibilities

3. Operational Scenarios

This section describes the operational scenarios of the high level business functions behind the concept of operations. As noted earlier, the concept of operations describes how stakeholders will work together to operate and maintain the ITS system. An overview of the scenarios is described in the table below. Following this description are process flow diagrams specific to each scenario that illustrate how stakeholders and systems work together to achieve operational goals.

Concept of Operation Scenario	Description
Interagency Signal coordination	• Describes interagency signal operations where traffic signal systems are coordinated across multiple jurisdictions. • Requires sharing of traffic information, infrastructure, and control among operating agencies. Such coordination could be facilitated by interagency agreements.
Signal Operations: Incident and Event Response (Pre-Planned and Ad-Hoc)	• Describes signal system operations in response to planned / unplanned events. • For planned events affecting the region, such as parades, heavy shopping periods, and maintenance / construction closures, traffic agencies work across jurisdictions to implement pre-developed timing plans. • For incidents / unexpected events, such as accidents / incidents on I-5 and / or US 101, either pre-developed or ad-hoc timing plans will be implemented.
Transit Signal Priority (TSP) Operation	• Describes operations for transit signal priority under a schedule based configuration (i.e., priority is granted if the bus is behind schedule). • Decisions on priority requests are made at the local intersection level, rather than from the central dispatch systems. • Onboard logic will determine the schedule adherence status of the vehicle. If the transit vehicle is operating on or ahead of schedule, the priority request will be denied; only those vehicles operating behind schedule by a designated number of minutes will be granted priority.
Transit Signal Priority (TSP) Configuration and Maintenance	• Describes configuration / implementation and maintenance support for TSP Operations. • Implementation includes activities such as developing signal timing plans that will be activated with TSP requests. • Maintenance activities include resolving / logging TSP failures, reconfiguring signals (through coordination with traffic agencies operating signals) and distributing maintenance / TSP performance logs to the agencies.
Regional Data Analysis and Performance Measurement	• Describes the collection of traffic / transit data from TRPC to assist in regional planning and performance analysis. • Under an interagency agreement, local transit / traffic agencies would provide TRPC with data in agreed upon formats, so the data could be accepted by TRPC's models and other analysis tools.

Exhibit E-10: Concept of Operation Scenarios

INSERT THE 11X17 VISIO/DPF FLOW DIAGRAMS**

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HIGH-LEVEL SYSTEM FUNCTIONAL REQUIREMENTS

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High-Level System Functional Requirements

1. Overview

Early in the Smart Corridors planning process, the participating agencies identified functional requirements based on project objectives for the near term and into the future. Requirements for the system were evaluated and prioritized through discussion with the Regional Traffic Operations Group (RTOG) facilitated by Thurston Regional Planning Council (TRPC).

This discussion led to a prioritization of system functions to meet the objectives of the project, the needs of participating agencies, and the available budget. Participants recognize the long-term value of increased operational capabilities supporting, for example, freeway incident management and traveler information. These functions however were deemed to be beyond the scope of the Smart Corridors project and the operating capabilities of the participating agencies. These enhancements are, however, noted in this document for future reference as potential system enhancements.

2. Core High-Level System Functional Requirements

Core High-Level System Functional Requirements for the Smart Corridors project are intended support the agencies' primary objectives of:

1. Improving traffic signal control capabilities.
2. Implementing regional, interoperable transit signal priority.

These core requirements are listed below, by sub-category.

2.1. Traffic Management System Requirements

- The system shall provide modern, state-of-practice traffic signal control capabilities to replace equipment at or near the end of its useful life with equipment designed and operable to current industry standards.
- The system shall provide the ability to implement traffic signal timing plans based on time of day, day of week, and special circumstances such as planned and non-planned events.
- The system shall support time-based traffic signal coordination of signals across multiple jurisdictions.
- The system shall support interoperability of traffic signal control equipment across jurisdictional boundaries, to promote regional traffic signal coordination where warranted.
- The system shall support, to the fullest extent possible, the use of standardized components for ease of maintenance and to minimize spare parts requirements.
- The system shall support remote traffic signal monitoring, maintenance, configuration, and analysis through a central traffic signal software platform.
- The system shall preserve existing coordination on arterial streets that are currently interconnected with signals located on the Smart Corridors.
- The system shall support the integration of a variety of traffic signal detection equipment, including loop, radar, and video detection devices.
- The system design shall, where practical and desirable, utilize existing traffic signal system components with valuable remaining service life.
- The system shall be designed to current WSDOT Standard Plans and Specifications, city special provisions, and Design Manual for traffic signal control equipment, as well as industry best practices.

2.2. Transit Signal Priority (TSP) System Requirements

- The system shall support regional TSP implementation on key Intercity Transit trunk routes through a system that is interoperable across jurisdictions.
- The system shall support conditional activation of TSP based on transit schedule adherence, prevailing traffic conditions, time since last call, and other factors supported by the traffic signal controller.
- The system shall interface with the Intercity Transit scheduling system to calculate schedule adherence values.
- The system shall support two-way data communications between the transit vehicle and TSP roadside equipment for purposes of TSP activation (call requests), retrieval of event logs, and transmission of configuration and maintenance files.
- The system shall provide two-way wireless data communications between the transit vehicle and the Intercity Transit backend systems through wireless communications at the Intercity Transit maintenance facility.

2.3. Emergency Signal Pre-Emption (ESP) System Requirements

- The system shall not impair the functionality and reliability of the existing multi-agency ESP System, which provides priority right-of-way for emergency vehicles approaching a traffic signal.
- The system shall maintain absolute priority of ESP requests over other traffic signal routines and transit signal priority requests.
- The system shall not require replacement of existing ESP equipment located on emergency response vehicles.
- The system shall be designed so that ESP requests always assume priority over TSP Requests.
- The system shall provide capabilities to restore normal traffic operations and signal plans following the activation of ESP.

2.4. Data, Monitoring, and Performance Measurement

- The system shall log critical operations, event, and error information for future retrieval, analysis, and diagnosis by the operating agencies.
- The system shall provide central traffic signal monitoring, reporting, and analytical capabilities through central signal control software to support maintenance / troubleshooting, signal timing plan implementation, and performance measurement by operating agencies.
- The system shall provide the ability to export traffic signal and TSP data (e.g. flow data, event logs) to support maintenance, performance measurement, and regional transportation planning functions.

3. Future Opportunities for Enhanced Functionality

Project participants recognized that the Smart Corridors project lays a foundation for future advance Transportation System Management and Operations (TSMO) capabilities in the Thurston region, including additional arterial management functions and coordination with WSDOT freeway management.

As part of the project planning, for example, agencies coordinated with WSDOT's regional Traffic Management Center, including an on-site meeting to discuss future traffic management capabilities that could be extended to the Thurston region within the lifetime of the proposed system.

The stakeholders in the Smart Corridors project agreed that ideally, the initial Smart Corridors infrastructure investment should support these functions in the future. However, given existing agency resources, staff capabilities, and the age of existing infrastructure, it was important to focus first on successful implementation of the basic traffic signal and TSP infrastructure.

Enhanced future functionality may be implemented in subsequent phases of the Smart Corridors project based on operational needs, the ability of the partners to support the operational responsibilities and technologies, and available funding for system implementation, operations, and maintenance.

Below are examples of functionality that may be developed in the future as system functional enhancements. A future phase of the Smart Corridors initiative, or an update of the regional ITS strategic plan, may be appropriate venues to discuss these and other long-term enhancements.

- In the future, the system may provide arterial video surveillance and detection, to support signal timing and maintenance, as well as incident management.
- In the future, the system may support integrated Corridor Management with parallel I-5 corridor, particularly along designated WSDOT freeway detour routes, through integration with the WSDOT TMC and additional arterial surveillance devices.
- In the future, the system may support regional coordination of traffic signal control systems through a regional or virtualized regional traffic control system.
- In the future, the system may provide Center-to-Center connections to the WSDOT Traffic Management Center for off-hours control and improved traffic surveillance and management coordination.
- In the future, the system may provide real-time traveler information capabilities, using field devices (e.g. Dynamic Message Signs) and leveraging WSDOT statewide assets such as 511 traveler information system.
- In the future, the system may provide arterial travel time detection (e.g. Bluetooth readers) for both agency performance measurement and public traveler information.
- In the future, the system may provide automated transmission and archiving of regional operations data as part of a Regional Transportation Data Archive project, in support of regional performance measurement.

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TAB G:

ITS ARCHITECTURE CONSISTENCY REVIEW

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ITS Architecture Consistency Review

1. Overview

The Regional ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems across agencies and modes, to maximize functionality and interoperability of those systems. Consistency with the Regional ITS Architecture insures that project implementations reflect the region's shared vision for deployment and integration of transportation technologies.

On January 8, 2001 the FHWA Final Rule on ITS Architecture and Standards Conformity (Final Rule) and the FTA Final Policy on Architecture and Standards Conformity (Final Policy) were enacted. The Final Rule and Final Policy ensures that ITS projects carried out using funds from the Highway Trust Fund including the Mass Transit Account conform to the National ITS Architecture and applicable ITS standards (see 23 CFR 940.11). This is implemented by ensuring consistency with the applicable Regional ITS Architecture.

The current Regional ITS Architecture for Thurston County is known as the Thurston Region System Architecture and was developed in 2002. The Regional ITS Architecture was developed under the supervision of the Thurston Regional Planning Council (TRPC) and is maintained by TRPC.

The Thurston Smart Corridors project is consistent with the Thurston Region System Architecture. The project team performed a consistency review as part of the Smart Corridors Systems Engineering process. All applicable ITS functionality, stakeholders, ITS elements, and information flows for the Smart Corridors project is contained within this Regional ITS Architecture.

2. Regional ITS User Services Included in Smart Corridors

The project incorporates the following ITS User Services for the project. Each of the proposed User Services is included in the Regional ITS Architecture:

PROJECT USER SERVICE	INCLUDED WITHIN THE REGIONAL ITS ARCHITECTURE?
Traffic Signal Control	Yes
Incident Management	Yes
Public Transportation Management	Yes
Archived Data	Yes

Exhibit G-1: User Services Included within the Regional ITS Architecture

3. Regional Service (Market) Packages Included in Smart Corridors

Through the needs assessment and scoping of the Smart Corridors project, the following service packages (formerly called Market Packages) from the Thurston Region System Architecture were identified as applicable to the Smart Corridors project.

Exhibit G-2 maps these service packages to the project's operational strategies:

SMART CORRIDORS OPERATIONAL STRATEGY	APPLICABLE THURSTON REGION SYSTEM ARCHITECTURE SERVICE (MARKET) PACKAGES
Traffic Signal Operations and Interagency Coordination	• ATMS01: Network Surveillance • ATMS03: Surface Street Control • ATMS07: Regional Traffic Control
Transit Signal Priority	• APTS07: Multi-Modal Coordination (Includes Transit Signal Priority)*
Regional Data Analysis and Performance Measurement	• AD2: ITS Data Warehouse

* Note that in the current Version 7 of the National ITS Architecture, Transit Signal Priority is a stand-alone Service Package (ATPS09). For Smart Corridors project purposes, the functionality represented is equivalent to the functionality in the Thurston Region System Architecture.

Exhibit G-2: Thurston Region System Architecture Service Packages Applicable to the Smart Corridors

4. Service Package Descriptions and Information Flows

This section includes descriptions and diagrams of the ITS Service Packages in the Thurston Regional ITS Architecture representing the Smart Corridors service described above:

4.1. ATMS01: Network Surveillance

4.1.1. Description

Service Package ATMS01 includes traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communications to transmit collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g. when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this service package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.

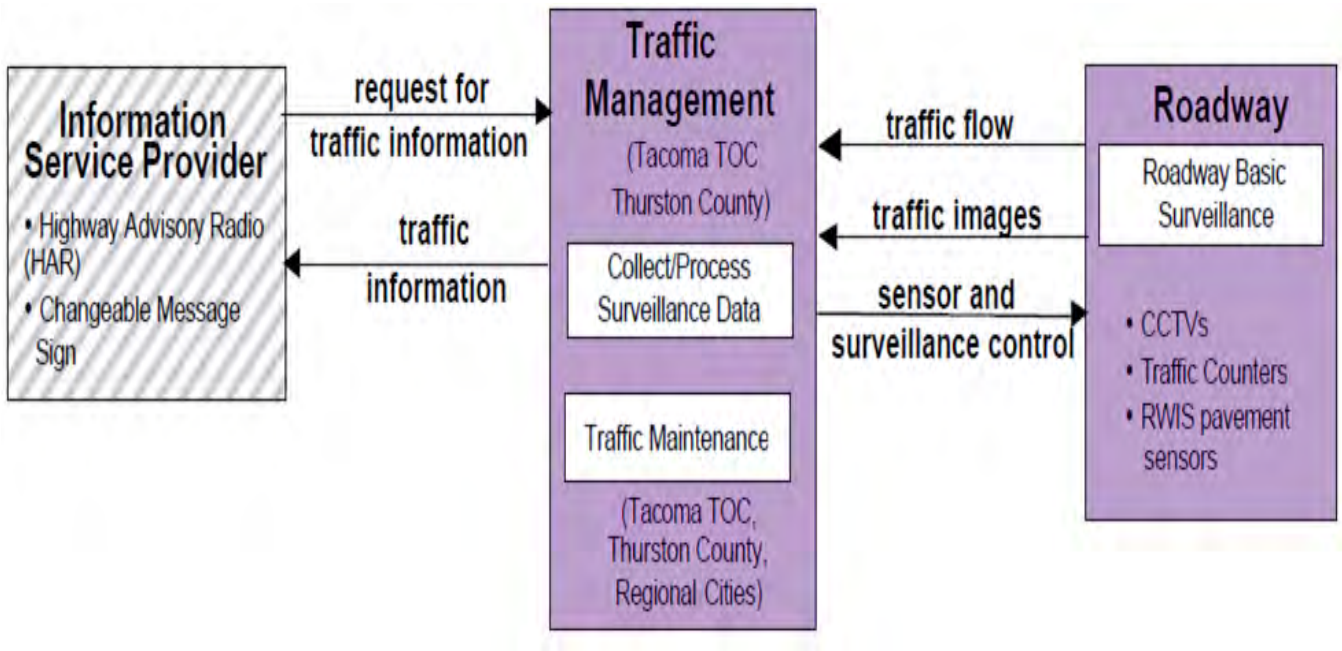

Exhibit G-3: Flow Diagram for ATMS01: Network Surveillance

4.1.2. Smart Corridors Information Flows

SMART CORRIDORS ITS ARCHITECTURE INFORMATION FLOWS		
between...	**...and**	**Flow**
Roadway	Traffic Management (Regional Cities)	Traffic Flow
Traffic Management (Regional Cities)	Roadway	Sensor and Surveillance Control

Exhibit G-4: Network Surveillance Information Flows

4.2. ATMS03: Surface Street Control

4.2.1. Description

Service Package ATMS03 provides for the sharing of traffic information and control among traffic management centers to support regional traffic management strategies. Regional traffic management strategies that are supported include inter-jurisdictional, real-time coordinated traffic signal control systems and coordination between freeway operations and traffic signal control within a corridor. This service package [provides] communications links and integrated control strategies that enable integrated, interjurisdictional traffic management. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Traffic Signal Control and Traffic Metering service packages and adds hardware, software, and fixed-point to fixed-point communications capabilities to implement traffic management strategies that are coordinated between allied traffic management centers. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.

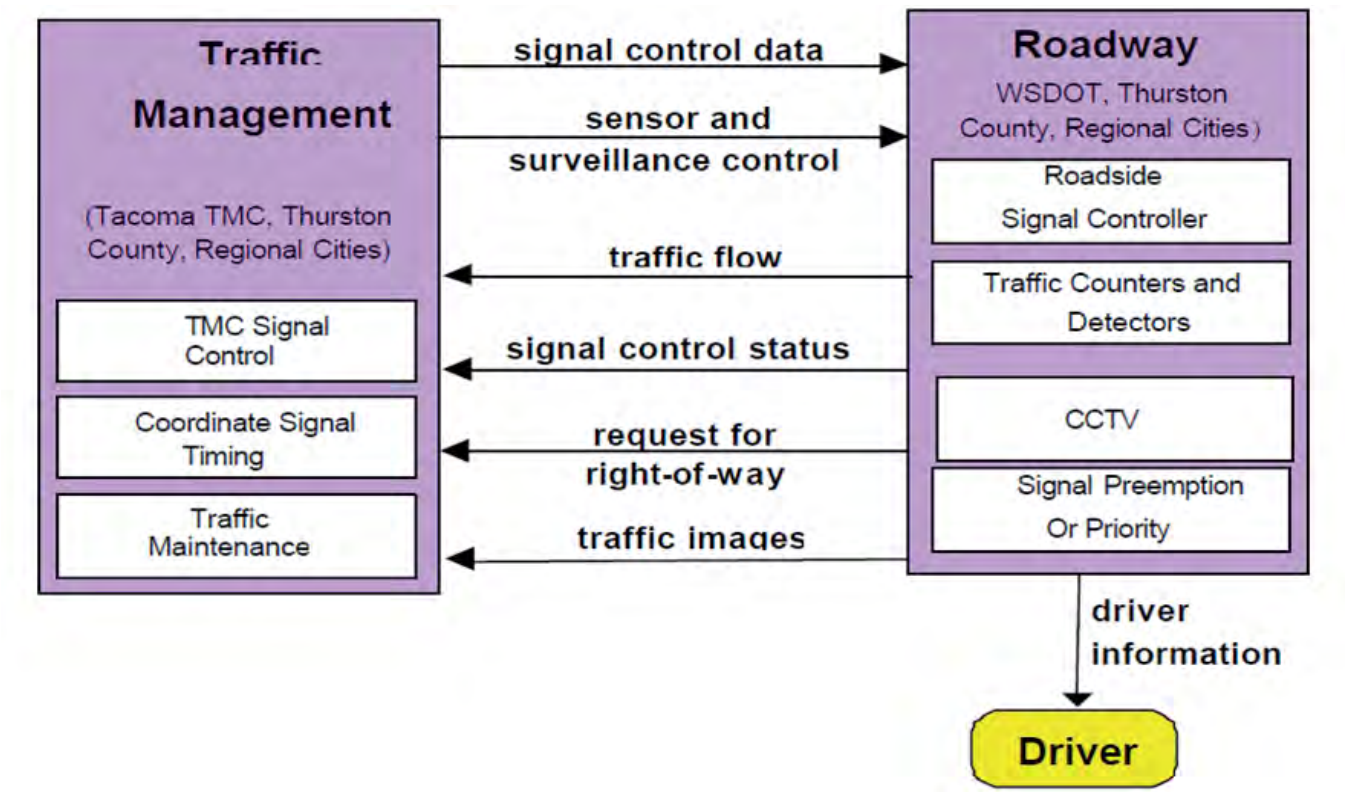

Exhibit G-5: Flow Diagram for ATMS03: Surface Street Control

4.2.2. Smart Corridors Information Flows

SMART CORRIDORS ITS ARCHITECTURE INFORMATION FLOWS		
between...	**...and**	**Flow**
Roadway	Traffic Management (Regional Cities)	Traffic Flow
Roadway	Traffic Management (Regional Cities)	Signal Control Status
Traffic Management (Regional Cities)	Roadway	Signal Control Data
Traffic Management (Regional Cities)	Roadway	Sensor and Surveillance Control

Exhibit G-6: Surface Street Control Information Flows

4.3. ATMS07: Regional Traffic Control

4.3.1. Description

Service Package ATMS07 provides the central control and monitoring equipment, communication links, and the signal control equipment that support traffic control at signalized intersections. A range of traffic signal control systems are represented by this service package ranging from fixed-schedule control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. This service package is generally an intra-jurisdictional package. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would also be represented by this package. This service package is consistent with typical traffic signal control systems.

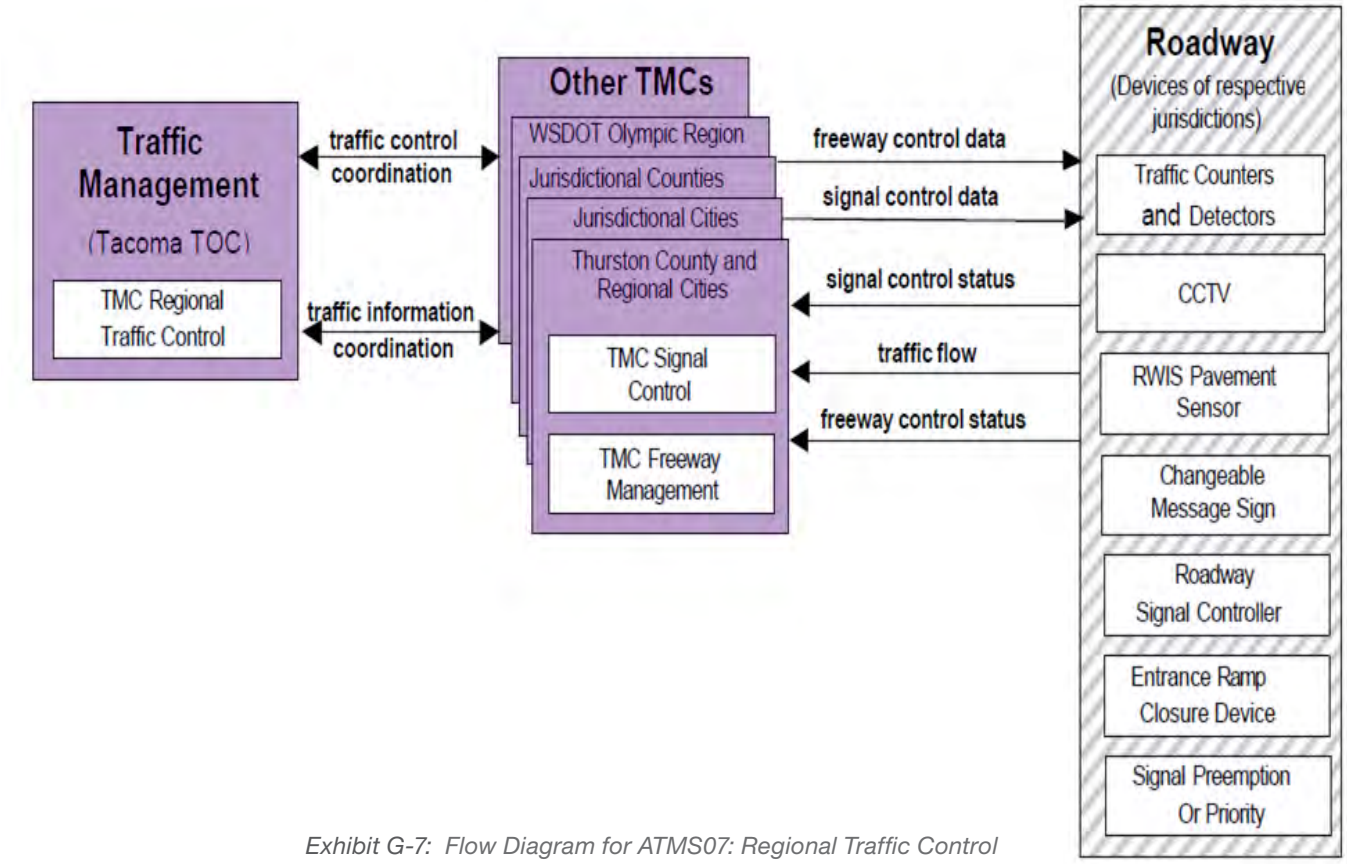

Exhibit G-7: Flow Diagram for ATMS07: Regional Traffic Control

4.3.2. Smart Corridors Information Flows

SMART CORRIDORS ITS ARCHITECTURE INFORMATION FLOWS		
between...	**...and**	**Flow**
Roadway	Traffic Management (Regional Cities)	Traffic Flow
Roadway	Traffic Management (Regional Cities)	Signal Control Status
Traffic Management (Regional Cities)	Roadway	Signal Control Data
Traffic Management (Regional Cities)	Traffic Management (Regional Cities)	Traffic Control Information
Traffic Management (Regional Cities)	Traffic Management (Regional Cities)	Traffic Information Coordination

Exhibit G-8: Regional Traffic Control Information Flows

4.4. APTS07: Multi-Modal Coordination (Transit Signal Priority)

4.4.1. Description

Among other functions, Service Package APTS07 determines the need for transit priority on routes and at certain intersections and requests transit vehicle priority at these locations. The signal priority may result from limited local coordination between the transit vehicle and the individual intersection for signal priority or may result from coordination between transit management and traffic management centers. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. (Note that in more recent versions of the National ITS Architecture, developed since the Thurston Region Systems Architecture was produced, the Transit Signal Priority Function is represented by its own market package, APTS09.)

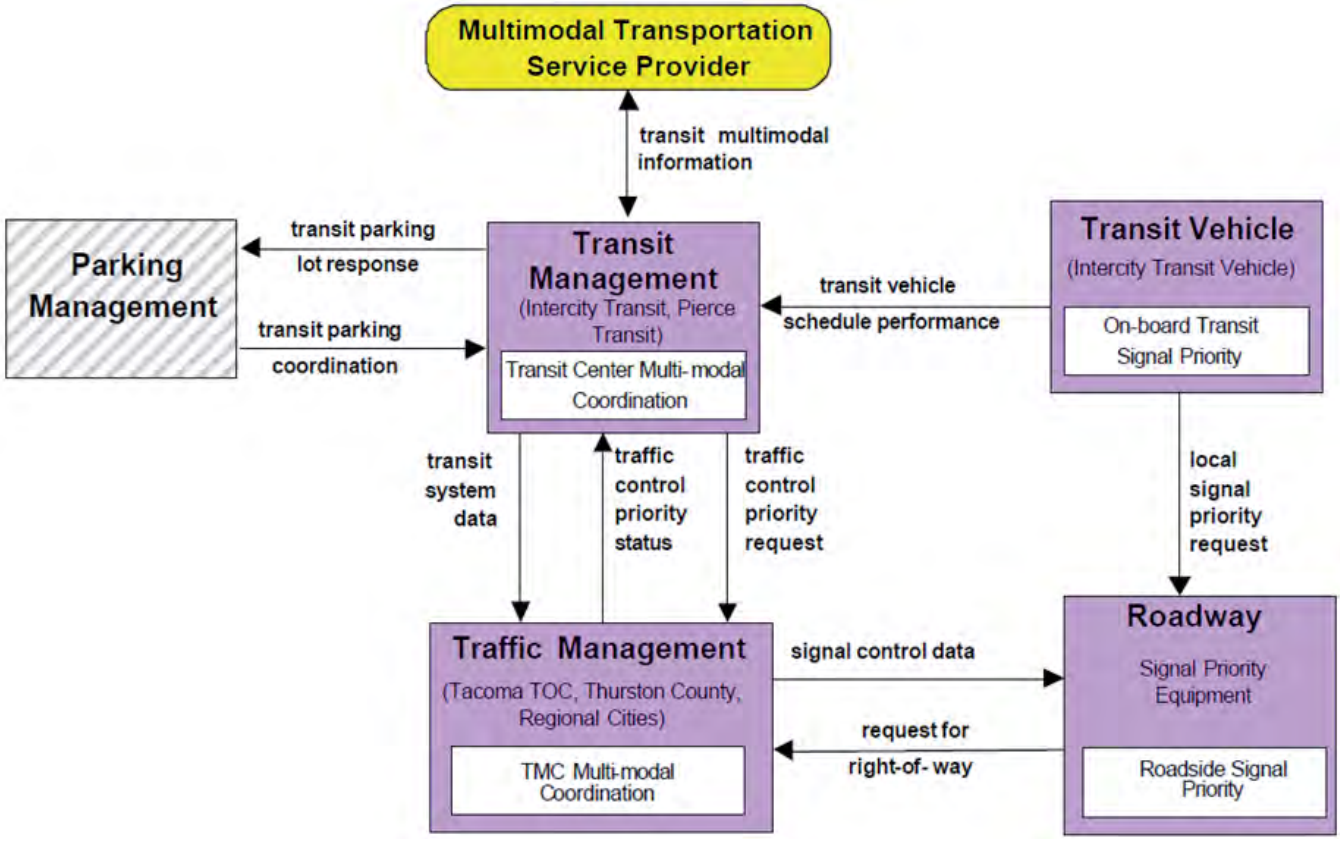

Exhibit G-9: Flow Diagram for APTS07: Multi-Modal Coordination (Transit Signal Priority)

4.4.2. Smart Corridors Information Flows

SMART CORRIDORS ITS ARCHITECTURE INFORMATION FLOWS		
between…	**…and**	**Flow**
Transit Vehicle	Transit Management (Intercity Transit)	Transit Vehicle Schedule Performance
Transit Vehicle	Roadway	Local Signal Priority Request
Roadway	Traffic Management (Local Cities)	Request for Right-of-Way
Traffic Management (Local Cities)	Roadway	Signal Control Data

Exhibit G-10: Multi-Modal Coordination (TSP) Information Flows

4.5. AD2: ITS Data Warehouse

4.5.1. Description

Service Package AD2 includes all the data collection and management capabilities provided by the ITS Data Mart, which is a focused archive that houses data collected and owned by a single agency. This package adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It provides additional functions and features that are necessary to manage data in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also included in this service package in addition to the basic query and reporting user access features offered by the ITS Data Mart.

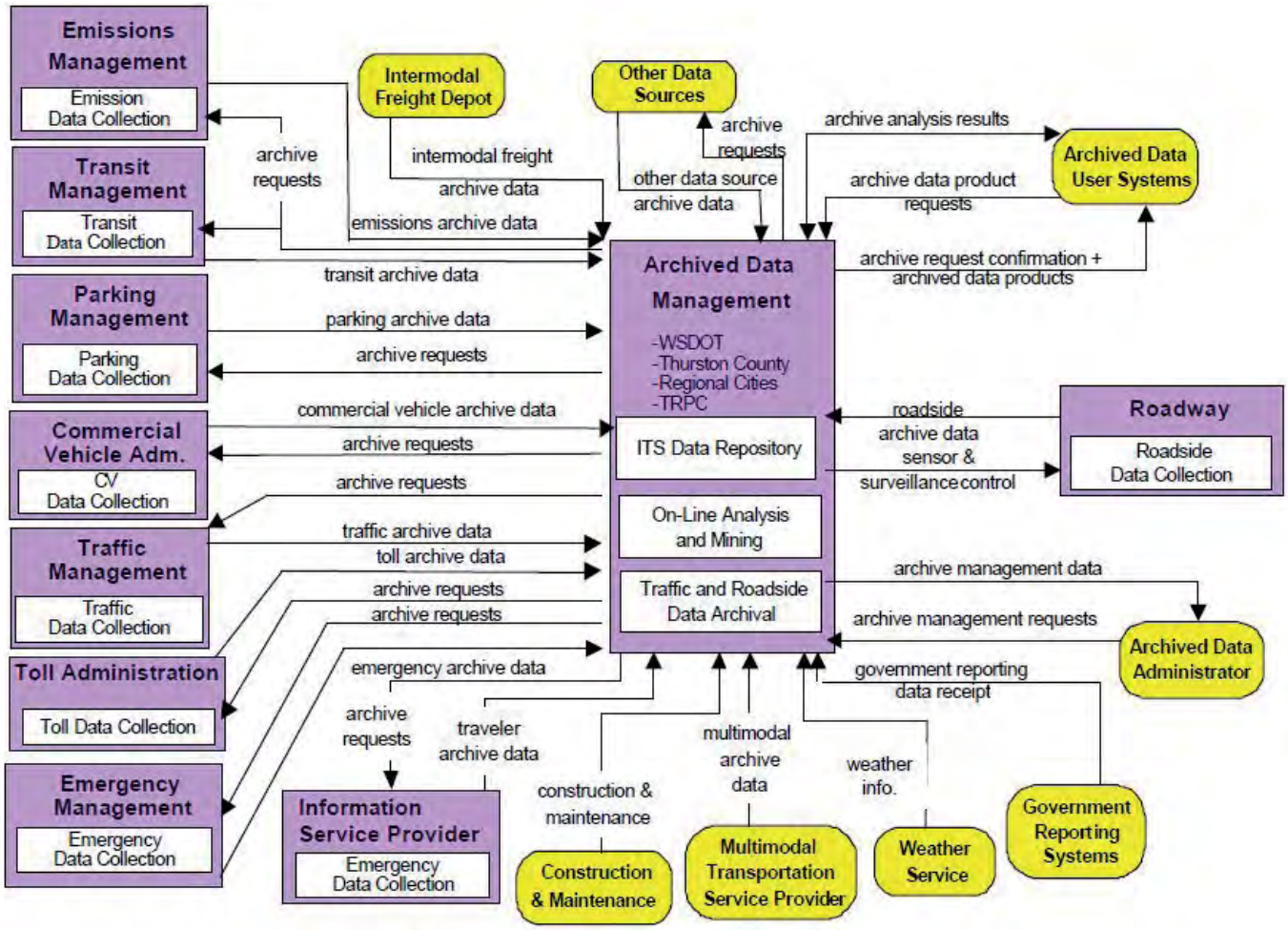

Exhibit G-11: Flow Diagram for AD2: ITS Data Warehouse

4.5.2. Smart Corridors Information Flows

SMART CORRIDORS ITS ARCHITECTURE INFORMATION FLOWS		
between...	**...and**	**Flow**
Roadway	Archived Data Management (Regional Cities, TRPC)	Roadway Archive Data
Archived Data Management (Regional Cities, TRPC)	Roadway	Sensor and Surveillance Control
Transit Management	Archived Data Management (Regional Cities, TRPC)	Transit Archive Data
Archived Data Management (Regional Cities, TRPC)	Transit Management	Archive Requests
Traffic Management	Archived Data Management (Regional Cities, TRPC)	Traffic Archive Data
Archived Data Management (Regional Cities, TRPC)	Traffic Management	Archive Requests

Exhibit G-12: ITS Data Warehouse Information Flows

5. Smart Corridors Physical Subsystems

The following physical subsystems are part of the Smart Corridors project. Again, each of the physical subsystems is currently included in the *Thurston Regional System Architecture*.

PHYSICAL SUBSYSTEMS FROM REGIONAL ITS ARCHITECTURE	SMART CORRIDORS PROJECT COMPONENTS AND RELATED SERVICE PACKAGES
Roadway Subsystem	• "Roadside Signal Controller" – Olympia, Tumwater, Lacey, Thurston County, WSDOT (ATMS 03, ATMS 07) • "Roadside Basic Surveillance" (Traffic Signal Detectors) Olympia, Tumwater, Lacey, Thurston County, WSDOT (ATMS 03, ATMS 07) • "Roadside Signal Priority" Equipment – Intercity Transit (ATMS 03, APTS07)
Traffic Management Subsystem	• "Traffic Management" – Olympia and Lacey Central Traffic Signal Control Systems (ATMS 03, ATMS 07)
Transit Management	• "Transit Management" – Intercity Transit Operations and Dispatch Facility (APTS07, AD 2)
Transit Vehicles	• "On-board Transit Signal Priority" – Intercity Transit Fixed-Route Coaches (APTS07)
Archived Data Management	• "Traffic and Roadside Data Archival" – Olympia, Lacey, Tumwater (AD2) • "ITS Data Repository" – Thurston Regional Planning Council ITS Data Repository (AD2)*

*Note that initially, data transfer from local agencies to TRPC is anticipated to be a manual process.

Exhibit G-13: Smart Corridors Physical Subsystems

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SMART CORRIDORS TECHNOLOGY ALTERNATIVES

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Smart Corridors Technology Alternatives

1. Overview

This chapter presents technology implementation alternatives for the Thurston Smart Corridors initiative. Candidate technologies include traffic signal coordination and optimization, TSP, and long-term support for advanced arterial and freeway management.

A phased technology deployment strategy is envisioned to meet both the near- and long-term objectives of the Smart Corridors initiative, taking into account both the desired functionality and the available resources to implement, operate, and maintain the systems.

The technology options presented in this document range from a low-cost alternative that makes the maximum use of existing equipment and infrastructure, to mid- and high-range solutions that rely on solutions with higher up-front costs in exchange for enhanced functionality and/or a longer service life. These tradeoffs are discussed throughout this report.

This report is intended to provide background information to support the regional dialogue on a preferred technology approach as well as definition of the Phase I Smart Corridors implementation project.

Costs presented in this report are planning estimates, based on recent project experience and information provided by the participating agencies. Field verifications of existing equipment types and conditions have not been conducted in preparing these estimates.

The technology approach and cost assumptions will continue to be refined as the project concept advanced towards the design and implementation phase. At this phase of project development, it is prudent to add a contingency to the anticipated project cost to account for unforeseen circumstances.

2. Smart Corridors System Architecture

2.1. Component Technology Systems

In general, four systems comprise the Thurston Smart Corridor technologies, which are owned, maintained, and operated by multiple jurisdictions in the region.

SMART CORRIDORS COMPONENT SYSTEMS	DESCRIPTION	OWNERSHIP AND OPERATING AGENCIES
Transit Management System (TMS)	Includes transit central system components and on-vehicle system components. For Intercity Transit, this is the ACS Computer Aided Dispatch/ Automatic Vehicle Location (CAD/AVL) system.	• Intercity Transit
Transit Vehicle Detection System	Including onboard transit vehicle equipment as well as roadside equipment.	• Intercity Transit (Onboard) • Traffic Signal Operating Agencies (Roadside)
Traffic Signal Control System (TSCS)	Includes central traffic signal control systems and roadside traffic signal equipment.	• Traffic Signal Operating Agencies (Roadside)
Communications System	The communications 'backbone' necessary to connect the central traffic signal control systems with the local intersection controllers.	• Traffic Signal Operating Agencies (Roadside)

Exhibit H-1: Four Systems of the Thurston Smart Corridor Technologies

The various Smart Corridor systems and subsystems are illustrated in *Exhibit H-2* and further described below. The potential system modifications required to support the Smart Corridors project are also identified and highlighted.

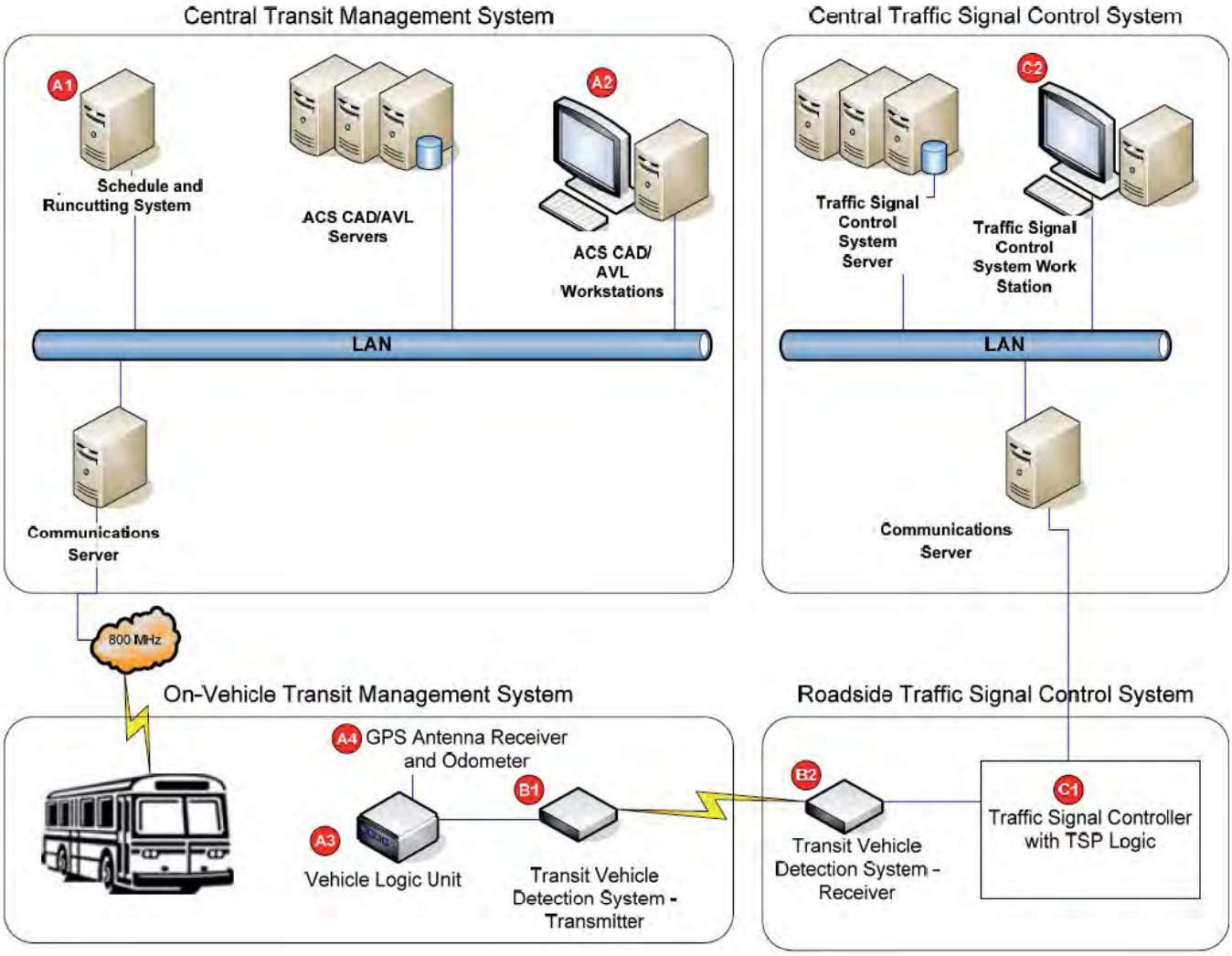

Exhibit H-2: Distributed Transit Signal Priority System Overview

2.2. Central Transit Management System

The following are the major sub-components of the Central Transit Management System:

- **A1 – Schedule Masters Schedule and Runcutting System** – This system is used for transit service planning. Typically, it stores route data including the route schedule and timing points. These timing points support conditional TSP, which is based on schedule adherence (i.e. request priority when off-schedule by 2 or more minutes). Also, the system typically stores the TSP assignment points (check-in/check-out) used to initiate the request for priority.

  Potential Smart Corridors Modifications: *No anticipated modifications are necessary, provided the existing schedule and runcutting software can store the TSP trigger points (check-in and check-out), and the lateness threshold for conditional priority.*

- **A2 – ACS (formerly Orbital) CAD/AVL System** – Transit dispatchers use this system to monitor route operations in real-time, and to make strategic control decisions regarding operations

  (i.e. insert a bus in the route, or short-turn a bus). The CAD/AVL interfaces with the Trapeze schedule and runcutting system to acquire route information, such as schedule timing points and TSP assignment points. The ACS CAD/AVL interfaces with the bus in the garage facilities through a wireless LAN (not shown in the previous exhibit) to download route information and upload TSP event logs. The TSP event logs include

details on the actual TSP check-in/check-out for each vehicle (date, time, GPS location, and text description of TSP assignment point).

Potential Smart Corridors Modifications: *The system software may be modified to perform active, conditional TSP.*

2.3. On-Vehicle Transit Management System

The following are the major sub-components of the On-Vehicle Transit Management System:

- **A3 – Vehicle Logic Unit (VLU)** – The VLU is an onboard computer that facilitates the CAD/AVL operations. The VLU uploads the schedule information from the CAD/AVL system in the garage. Once en-route, the VLU tracks the vehicles progress against the schedule information using a combination of Global Positioning System (GPS) and odometer readings. When the vehicle is at a check-in TSP assignment point, the VLU checks if the conditions for TSP have been met (i.e. off schedule by more than 1 minute or more). If the conditions are met, the VLU initiates the request for priority using the transit vehicle detection system (B1). When the vehicle is at a check-out TSP assignment point, the VLU cancels the request for priority. The VLU logs all TSP activity, which is uploaded to the CAD/AVL for analysis. Depending on the transit vehicle detection system used, the VLU can report faults with onboard equipment.

  Potential Smart Corridors Modifications: *The onboard VLU may be modified, along with the CAD/AVL system to provide active, conditional TSP.*

2.3.1. Transit Vehicle Detection System

- **B1 – On-vehicle Transit Vehicle Detection System Device** – The on-vehicle transit vehicle detection system component interfaces with the VLU (A3). When the VLU initiates the request for priority, this device relays the request for priority to the signalized intersection. The communication to the roadside may be as simple as a request for priority, or may be more complex and include additional information, such as the specific bus number.

  Potential Smart Corridors Modifications: *A transit vehicle detection system must be installed as part of this project for transit signal priority. The on-vehicle transit vehicle detection system may interface with the VLU for active, conditional TSP. As an option, the on-vehicle transit vehicle detection system could operate independently, most- likely in an unconditional TSP mode.*

2.4. Roadside Traffic Signal Control System

- **B2 – Roadside Transit Vehicle Detection System Components** – The roadside transit vehicle detection system components include a receiver and a roadside computer. The receiver reads the request for priority from the transit vehicle and relays the priority request to the roadside computer. The roadside computer is responsible for deciphering the priority request and issuing the request for priority to the traffic signal control system. The roadside computer also records TSP event logs, and typically can identify system faults, such as the priority request having exceeded a predetermined threshold time duration.

  Potential Smart Corridors Modifications: *The associated roadside transit vehicle detection system components will be installed to ensure compatibility with onboard equipment, emergency preemption equipment, and in light of a available cabinet space. There are several technologies that can be used for this project.*

2.5. Central Traffic Signal Control System

- **C1 – Traffic Signal Controller** – The traffic signal controller receives the request for priority from the transit vehicle detection system, and implements the transit priority routine (typically green extension or early phase activation). The traffic signal controller records the TSP event log (date, time, and input), and typically has

some system fault capabilities.

Potential Smart Corridors Modifications: *There is a range in traffic signal controller options depending on the existing controller. Options include: upgrade existing controller, replacing existing controller, and replacing existing controller-cabinet assembly.*

- **Central Traffic Signal Control System Software** – The central traffic signal control system software can typically monitor the intersection operation in real-time, and includes a database for storing traffic signal control system data. The central traffic signal control system stores the intersection controller data, including the TSP parameters such as green extension duration and TSP event logs recorded in the traffic signal controller (C1).

  Potential Smart Corridors Modifications: *There are two main options for the central traffic signal control system software. In the first option, each agency has its own central software, which at a later date may be integrated through a center-to-center (C2C) application. The C2C application will provide the "active management" of the project corridor that is ultimately envisioned. In the second option, a regional traffic signal system is implemented. This regional system can communicate with all signalized intersections within the project corridor. Again, active management is feasible through this regional system.*

2.6. Communication System

To support the above TSP architectural components and facilitate the exchange of transit and traffic data, a communication network needs to be design and constructed for each agency's traffic signal control signal system.

The details of the communication network are a function of the existing network and the TSP system that is ultimately implemented. Several options are presented later in this report.

2.7. Smart Corridors Intersections

Based on information provided by the operating jurisdictions there are 78 signalized intersections within project limits.

Among the 78 signalized intersections, 50 signalized intersections are located directly on the two Smart Corridors. An additional three signalized intersections, which are located adjacent "spurs" to the corridor, facilitate the movement of transit vehicle from the Smart Corridor into and out of the Lacey and Tumwater Transit Centers, which are located off of the Smart Corridors themselves.

The remaining 25 signalized intersections are interconnected with Smart Corridors intersections through the agency communications networks. Controller upgrades to Smart Corridors signals may 'trigger' upgrades at other intersections if the equipment is not compatible and/or of the operating agencies wish to maintain or implement a coordinated system. This factor needs to be taken into account in defining the boundaries and budget of the Smart Corridors project. *Exhibit H-3* on the next page was derived from existing information provided by the jurisdictions; additional existing interconnects may exist but have not been field verified.

INTERSECTION CATEGORY	INTERSECTION SUB-GROUP	INTERSECTIONS IN SUB-GROUP	CATEGORY SUBTOTAL
SMART CORRIDORS INTERSECTIONS (Intersections located directly on the Smart Corridors between the project limits)	Capitol Blvd/Way	17	
	Martin Way/4th/State	33	50
SPUR INTERSECTIONS (Other intersections between project limits on Intercity Transit Routes 13 and 62 A/B)	Tumwater Square Transit Center (Cleveland Ave)	2	
	Lacey Transit (Sleater-Kinney Rd)	1	3
INTERCONNECT NETWORKS (Other intersections that are currently operationally interconnected/coordinated with Smart Corridors intersections)	4th St. (Olympia)	4	
	State St. (Olympia)	1	
	Capitol Way (Olympia)	0	
	Lilly Rd. Interconnect (Olympia)	3	
	Central Lacey (Lacey)	17	
	WSDOT	0	
	Thurston County	0	
	Tumwater	0	25
TOTAL SMART CORRIDORS INTERSECTIONS			**78**

Exhibit H-3: Project Signalized Intersections (Planning-Phase Estimate)

3. Local Intersection Controller Alternatives

This section discusses options and cost estimates for upgrading existing local intersection controllers along the Smart Corridor jurisdictions. This material was developed in 2010 during preliminary project planning. It is provided as background information only. The strategy selected for the project is a blend of the alternatives discussed in this chapter.

3.1. Existing Controller Inventory and Migration Options

Exhibit H-4 groups the Smart Corridor signalized intersections (53 in total that include the three "spur" intersections along with the primary 50 directly on the Smart Corridors) by controller type, controller software, and cabinet type. Interconnected signalized intersections are also presented.

OWNED BY	OPERATED BY	MAINTAINED BY	CON-TROLLER	SOFTWARE	CABINET	SMART CORRIDOR	INTER-CONNECTED
Olympia	Olympia	Olympia	170	Bitrans (233 rev 2.8b)	Model 332	10	
Olympia	Olympia	Olympia	170	Bitrans (233 rev 2.8b)	Model 338	19	
Olympia			TBD				8
Lacey	Lacey	Lacey	Traconex TMP-390	v4	NEMA "P"	2	
Lacey	Lacey	Lacey	Traconex TMP-390	J8	NEMA "P"	2	
Lacey	Lacey	Lacey	Traconex TMP-390	J9	NEMA "P"	1	
Lacey			TBD			2	
Lacey			TBD				17
Thurston County	Lacey	Lacey	Traconex TMP-390	v4	NEMA "P"	4	
Thurston County							0
WSDOT OR	Lacey/ WSDOT	Lacey	Traconex TMP-390	J8	NEMA "P"	2	
WSDOT OR							0
Tumwater	Tumwater	Tumwater	ASC/2		NEMA "P"	6	
Tumwater	Tumwater	Tumwater	ASC/3	v5 2.44.2	NEMA "P"	2	
Tumwater	Tumwater	Tumwater	Traconex TMP-390	J8	NEMA "P"	2	
Tumwater			TBD			1	
Tumwater			TBD				TBD
					Subtotal	**53**	**25**
					Total		**78**

Exhibit H-4: Controller Inventory

Based on *Exhibit H-4* , the Smart Corridor controller cabinet assemblies can be grouped into the following categories based on controller type, namely:

1. 170 Controller (Olympia): BiTrans 233 rev 2.8b software operating in either a Model 332 or 338 cabinet. This controller represents 29 signalized intersections owned by Olympia.
2. Traconex TMP-390 (Lacey, Thurston County, WSDOT, Tumwater): This controller uses three software types,v4, J8 and J9, all in a NEMA P cabinet. The Traconex TMP-390 represents 13 signalized intersections owned by Lacey (5), Thurston County (4), WSDOT (2) and Tumwater (2).
3. Econolite ASC (Tumwater): Econolite ASC/2 or ASC/3 operating in a NEMA P cabinet. In total this represents 8 signalized intersections owned by Tumwater.

Controller details are unknown for two Lacey signalized intersections and one Tumwater signalized intersection. For analysis purposes, it is assumed that these are Traconex TMP-390 controller cabinet assemblies, since these will be the most expensive to upgrade/replace.

3.2. Controller Technology Options

The following three enhancement options were considered for each signalized intersection:

- **Option 1:** upgrade/enhance existing controller;
- **Option 2:** replace existing controller, and keep existing cabinet; and
- **Option 3:** replace existing controller cabinet assembly.

The following describes the enhancement options for each of the three controller modifications identified above. These options were generated through the recent vendor presentation, discussions with the project team, and through follow up discussions with the vendor; however, not all options can be applied to each signal controller.

3.2.1. 170 Controller

The three options for the 170 controller include:

- **Option 1:** Upgrade the existing software from 233 rev 2.8b to MC1 or 233 rV2 chipset, which supports TSP;
- **Option 2:** Replace the existing controller, and install a 2070 controller operating McCain 2033; and
- **Option 3:** Replace the existing controller-cabinet assembly with a new 2070 controller cabinet assembly.

3.2.2. Traconex TMP-390

For the Traconex TMP-390 controller, only two options are available that include:

- **Option 2:** Replace the existing Traconex TMP-390 controller with a 2070N controller operating Econolite ASC/3 NEMA software. Alternatively, replace the existing Traconex TMP-390 controller with an Econolite ASC/3 NEMA TS2 Type 2 controller; and
- **Option 3:** Replace the existing controller-cabinet assembly with a new 2070 controller cabinet assembly.

3.2.3. Econolite ASC

Econolite no longer supports the ASC/2 controller. As a result, it is unlikely that the existing Econolite ASC/2 controllers can be upgraded to include TSP through a chipset change. More than likely the existing ASC/2 controllers will be replaced with ASC/3 controllers. The TSP logic in the Econolite ASC/3 controller will be activated through the Econolite “blue key”.

Therefore, the following two options are available for the Econolite ASC controller:

- **Option 1:** Applies only to ASC/3 controller, which can support TSP through the activation of the TSP logic; and
- **Option 2:** Applies on to ASC/2 controllers, which will be replaced with ASC/3 controllers.

3.3. Budgetary Estimate

The enhancement options were categorized into the three general implementation strategies below:

- **Strategy 1:** Low cost – only upgrade the necessary equipment to support TSP
- **Strategy 2:** Controllers – replace the existing controllers, but keep the cabinet assemblies. This strategy reduces the overall installation cost, by reusing the existing cabinet assemblies. In general, the main advantage over strategy 1 is the support of broadband communications and networking options by the new controllers.
- **Strategy 3:** Controller Cabinet Assemblies – replace the existing controller cabinet assembly and install a new controller cabinet assembly that is either NEMA or 2070 based depending on the agency specific direction. The exception is the relatively new Econolite traffic signal control equipment. Functionally, this strategy does not provide additional performance in comparison to Strategy 2; however, it does refresh the aging infrastructure (particularly the Traconex equipment).

The following table summarizes the migration options for each controller category. Options 1 and 2 are the same for the Traconex TMP-390 controllers, and Options 2 and 3 are the same for the Econolite ASC controllers.

CONTROLLER CATEGORY (JURISDICTION)	OPTION 1 – LOW COST	OPTION 2 – CONTROLLERS	OPTION 3 – CONTROLLER CABINET ASSEMBLIES
170 Controller (Olympia)	Upgrade existing controller Chipset to BERKO chipset	Replace existing 170 controller with 2070 controller operating software version 2033	Replace existing controller cabinet assembly with new 2070 controller cabinet assembly, operating software version 2033
Traconex TMP-390 (Lacey, Thurston County, WSDOT, Tumwater)	Replace existing Traconex controller with Econolite NEMA ASC/3, or 2070N operating ASC/3 software	Replace existing Traconex controller with Econolite NEMA ASC/3, or 2070N operating ASC/3 software	Replace existing controller cabinet assembly with Econolite NEMA ASC/3 TS2 Type 1, or 2070 operating ASC/3
Econolite ASC (Tumwater)	Replace ASC/2 controller with ASC/3 Activate TSP logic in Econolite ASC/3	Replace ASC/2 controller with ASC/3. Activate TSP logic in ASC/3	Replace ASC/2 controller with ASC/3. Activate TSP logic in ASC/3

Exhibit H-5: Migration Options by Controller Category

ITEM NO.	ITEM DESCRIP-TION	QTY	STRATEGY 1 - LOW COST		STRATEGY 2 - CONTROLLERS		STRATEGY 3 - CONTROLLER CABINET	
			Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost
Supply								
S.C.1	170 Controller	29	$150	$4,350	$3,200	$92,800	$15,000	$435,000
S.C.2	Traconex TMP-390	16	$3,500	$56,000	$3,500	$56,000	$15,000	$240,000
S.C.3	Econolite ASC/2	6	$3,500	$21,000	$3,500	$21,000	$3,500	$21,000
S.C.4	Econolite ASC/3	2	$1,000	$2,000	$1,000	$2,000	$1,000	$2,000
Installation								
I.C.1	170 Controller	29	$500	$14,500	$500	$14,500	$5,000	$145,000
I.C.2	Traconex TMP-390	16	$1,000	$16,000	$1,000	$16,000	$5,000	$80,000
I.C.3	Econolite ASC/2	6	$500	$3,000	$500	$3,000	$500	$3,000
I.C.4	Econolite ASC/3	2	$ -	$-	$ -	$ -	$ -	$ -
		Total		**$116,850**		**$205,300**		**$926,000**

Exhibit H-6: Smart Corridor Controller Replacement Budgetary Estimate (Planning Phase - see current Design Phase estimate for updated information)

ITEM NO.	ITEM DESCRIP-TION	QTY	STRATEGY 1 - LOW COST		STRATEGY 2 - CONTROLLERS		STRATEGY 3 - CONTROLLER	
			Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost
Olympia								
S.C.1	170 Controller	36	$150	$5,400	$3,200	$115,200	$15,000	$540,000
I.C.1	170 Controller	36	$500	$18,000	$500	$18,000	$5,000	$180,000
		Subtotal		**$23,400**		**$133,200**		**$720,000**
Lacey								
S.C.2	Traconex TMP-390	7	$3,500	$24,500	$3,500	$24,500	$15,000	$105,000
I.C.2	Traconex TMP-390	7	$1,000	$7,000	$1,000	$7,000	$5,000	$35,000
		Subtotal		**$31,500**		**$31,500**		**$140,000**
Thurston County								
S.C.2	Traconex TMP-390	5	$3,500	$17,500	$3,500	$17,500	$15,000	$75,000
I.C.2	Traconex TMP-390	5	$1,000	$5,000	$1,000	$5,000	$5,000	$25,000
		Subtotal		**$22,500**		**$22,500**		**$100,000**
WSDOT								
S.C.2	Traconex TMP-390	2	$3,500	$7,000	$3,500	$7,000	$15,000	$30,000
I.C.2	Traconex TMP-390	2	$1,000	$2,000	$1,000	$2,000	$5,000	$10,000
		Subtotal		**$9,000**		**$9,000**		**$40,000**
Tumwater								
S.C.2	Traconex TMP-390	2	$3,500	$7,000	$3,500	$7,000	$15,000	$30,000
I.C.2	Traconex TMP-390	2	$1,000	$2,000	$1,000	$2,000	$5,000	$10,000
S.C.3	Econolite ASC/2	7	$3,500	$24,500	$3,500	$24,500	$3,500	$24,500
I.C.3	Econolite ASC/2	7	$500	$3,500	$500	$3,500	$500	$3,500
S.C.4	Econolite ASC/3	2	$1,000	$2,000	$1,000	$2,000	$1,000	$2,000
S.C.4	Econolite ASC/3	2	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal		**$39,000**		**$39,000**		**$70,000**
		Total		**$125,400**		**$235,200**		**$1,070,000**

Exhibit H-7: Smart Corridor Controller Replacement Budgetary Estimate by Agency

Exhibit H-8 provides a budgetary estimate of the supply and installation costs associated with the controller replacement strategies for the Smart Corridor signalized intersections and the interconnected signalized intersections.

ITEM NO.	ITEM DESCRIP-TION	QTY	STRATEGY 1 - LOW COST		STRATEGY 2 - CONTROLLERS		STRATEGY 3 - CONTROLLER CABINET	
			Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost
Supply								
S.C.1	170 Controller	37	$150	$5,550	$3,200	$118,400	$15,000	$555,000
S.C.2	Traconex TMP-390	33	$3,500	$115,500	$3,500	$115,500	$15,000	$495,000
S.C.3	Econolite ASC/2	6	$3,500	$21,000	$3,500	$21,000	$3,500	$21,000
S.C.4	Econolite ASC/3	2	$1,000	$2,000	$1,000	$2,000	$1,000	$2,000
Installation								
I.C.1	170 Controller	37	$500	$18,500	$500	$18,500	$5,000	$185,000
I.C.2	Traconex TMP-390	33	$1,000	$33,000	$1,000	$33,000	$5,000	$165,000
I.C.3	Econolite ASC/2	6	$500	$3,000	$500	$3,000	$500	$3,000
I.C.4	Econolite ASC/3	2	$ -	$ -	$ -	$ -	$ -	$ -
		Total		**$198,550**		**$311,400**		**$1,426,000**

Exhibit H-8: Controller Replacement Budgetary Estimate

ITEM NO.	ITEM DESCRIP-TION	QTY	STRATEGY 1 - LOW COST		STRATEGY 2 - CONTROLLERS		STRATEGY 3 - CONTROLLER	
			Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost
Olympia								
S.C.1	170 Controller	37	$150	$5,550	$3,200	$118,400	$15,000	$555,000
I.C.1	170 Controller	37	$500	$18,500	$500	$18,500	$5,000	$185,000
		Subtotal		**$24,050**		**$136,900**		**$740,000**
Lacey								
S.C.2	Traconex TMP-390	24	$3,500	$84,000	$3,500	$84,000	$15,000	$360,000
I.C.2	Traconex TMP-390	24	$1,000	$24,000	$1,000	$24,000	$5,000	$120,000
		Subtotal		**$108,000**		**$108,000**		**$480,000**
Thurston County								
S.C.2	Traconex TMP-390	4	$3,500	$14,000	$3,500	$14,000	$15,000	$60,000
I.C.2	Traconex TMP-390	4	$1,000	$4,000	$1,000	$4,000	$5,000	$20,000
		Subtotal		**$18,000**		**$18,000**		**$80,000**
WSDOT								
S.C.2	Traconex TMP-390	2	$3,500	$7,000	$3,500	$7,000	$15,000	$30,000
I.C.2	Traconex TMP-390	2	$1,000	$2,000	$1,000	$2,000	$5,000	$10,000
		Subtotal		**$9,000**		**$9,000**		**$40,000**
Tumwater								
S.C.2	Traconex TMP-390	3	$3,500	$10,500	$3,500	$10,500	$15,000	$45,000
I.C.2	Traconex TMP-390	3	$1,000	$3,000	$1,000	$3,000	$5,000	$15,000
S.C.3	Econolite ASC/2	6	$3,500	$21,000	$3,500	$21,000	$3,500	$21,000
I.C.3	Econolite ASC/2	6	$500	$3,000	$500	$3,000	$500	$3,000
S.C.4	Econolite ASC/3	2	$1,000	$2,000	$1,000	$2,000	$1,000	$2,000
I.C.4	Econolite ASC/3	2	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal		**$39,500**		**$39,500**		**$86,000**
		Total		**$198,550**		**$311,400**		**$1,426,000**

Exhibit H-9: Controller Replacement Budgetary Estimate by Agency

4. Central Traffic Signal Control System Software

This section discusses options and cost estimates for upgrading existing traffic signal control system central software for the intersections along the Smart Corridors.

4.1. Existing Systems

There are three existing traffic signal control system central software in use in the project area:

- **QuicNet 4 –** operated by City of Olympia;
- **Traconex –** operated by City of Lacey, and includes Thurston County and WSDOT signalized intersections;
- **Aries –** operated at select signalized intersections in the City of Tumwater.

4.2. Migration Options

Based on the initial discussions with the project team, two options for upgrading the central traffic signal control system were identified. The upgrade can be done through:

1. Individual Central Traffic Signal Control Systems, and/or
2. The Regional Traffic Signal Control System.

4.2.1. Upgrade by Individual Central Traffic Signal Control Systems

In the first option, each agency has a central traffic signal control system that facilitates communication with their corridor signalized intersections. Signalized intersections are coordinated across jurisdictional boundaries through the establishment of a common time reference. Agencies maintain coordination between adjacent signalized intersections (when necessary) in different jurisdictions by meeting periodically to establish common signal timing practices. In a future project task, the individual central traffic signal control systems can communicate via a Center to Center (C2C) interface.

Based on an assessment of the existing traffic signal control systems, the Econolite Aries and Traconex systems cannot be upgraded. Also, McCain indicated that their new traffic signal control system is not yet available. As a result, the most-likely central traffic signal control systems for option 1 are:

- Olympia: Enhance existing McCain QuicNet system to support the new controllers for TSP; and
- Tumwater and Lacey (including Thurston County and WSDOT): Procure an Econolite Centracs system.

4.2.2. Upgrade by Regional Traffic Control System

In the second option, one regional traffic signal control system communicates with each signalized intersection. Each agency has access to their signalized intersections through the regional traffic signal control system. Moreover, agencies can view signalized intersections operated by other agencies, but cannot change operating parameters.

In order for the second option to be feasible, all traffic signal controllers within the project area need to be NTCIP compliant. In addition, the vendor specific MIBS required for TSP needs to be available to the traffic signal control system vendor to incorporate into the new system.

In the second option, potentially both McCain and Econolite could bid for a Regional system. It is difficult to assess the exact cost of this Regional system at this time. The cost includes negotiating with each vendor to obtain their communications protocol to support TSP, or potentially reverting to the TSP logic available in the NTCIP protocol. It is important to note that the 2033 controller software is not NTCIP compliant. ***For this reason the Regional traffic signal control system will not be considered for this project.***

4.3. Budgetary Estimate

As described above, only option 1,software upgrade by individual traffic signal control systems, is practical for this project. As a result, the only central traffic signal control system migration strategy includes:

- Olympia: Enhance existing McCain QuicNet system to support the new controllers for TSP; and
- Tumwater and Lacey (including Thurston County and WSDOT): Procure an Econolite Centracs system.

Exhibit H-10 presents a budgetary estimate for the traffic signal control system central software.

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT COST ($)	TOTAL COST ($)
Olympia				
S.S.1	QuicNet 4 Upgrade (including server)	1	$20,000	$20,000
I.S.1	Installation and training	1	$10,000	$10,000
			Subtotal	**$30,000**
Lacey				
S.S.2	Econolite Centracs (including server)	1	$350,000	$350,000
I.S.2	Installation and training	1	$25,000	$25,000
			Subtotal	**$375,000**
Tumwater				
S.S.3	Econolite Centracs (including server)	1	$350,000	$350,000
I.S.3	Installation and training	1	$25,000	$25,000
			Subtotal	**$375,000**
			Total	**$780,000**

Exhibit H-10: Central Traffic Signal Control System Budgetary Estimate

As presented in *Exhibit H-10* , the central traffic signal control system budgetary estimate is $780,000. However, once the new McCain traffic signal control system is formally released, the cost of the new system should approach the cost of the Econolite Centracs system ($375,000). If the Centracs system is selected by the City of Olympia, then the central traffic signal control system budgetary estimate would increase to $1,125,000.

5. Traffic Signal System Communication Network

This section describes the functional requirements for the communication system and investigates the feasible network design alternatives.

5.1. Overall Communication Network Requirement

A communications network is a facility needed to interconnect nodes constituting different sub networks, and to provide a path for the exchange of information between them. In our experience, the communications network strategy for each transportation and traffic management project is unique because each project has specialized communications requirements, unique geographical constraints, and multiple service providers and services operating in the areas of interest.

For this project, a reliable network is needed to effectively deploy and transfer data between Transit Management System, Transit Vehicle Detection System, and Transit Signal Control System. Interested stakeholders in the design and development of the communication network include:

- City of Olympia
- City of Lacey
- City of Tumwater
- WSDOT
- Thurston County

5.2. Communication Network Design Options

Several wired and wireless technologies may be considered for a backbone network. The wired options include Coaxial Cable, Twisted Pair Copper, and Fiber. The wireless technology options include CDMA wireless and various licensed and license-exempt radio systems. Due to high operational costs and concerns over service levels with service providers, the CDMA wireless, and the coaxial cable with cable modem options are not considered optimal on-route network backbone options.

The following sections analyze the feasibility and compare high level costs for each of the remaining options.

It is known that there is no single Traffic Management Center. Therefore, it is assumed that the agencies will operate and manage the data and traffic from their premises.

5.2.1. Wired Design Option - Fiber

The three strategies for deploying fiber network in the Smart Corridors include:

- Traditional deep buried fiber;
- Traditional aerial fiber; and
- “Micro-Trenching” - This is a low-impact deployment methodology in which fiber and conduit are inserted into a slot-cut trench less than 3/4 inch wide and between 9 and 12 inches deep – without damaging or disrupting existing infrastructure. In fact, when the trench is properly reinstated and backfilled with a cold asphalt material, it is difficult for the casual observer to see it. The cost savings, speed of deployment and reduction in resources over conventional trenching are significant.

5.2.2. Wired Design Option - Leverage Existing Copper

It is understood that there is twisted copper laid throughout the two proposed corridors. However, the availability of these circuits for the project is not known at this point-in-time. If this was an available option, traffic signal system

could communicate on copper network. One of the feasible options is Ethernet over DSL (Digital Subscriber Line). DSL refers to the data communication technology which uses the existing copper telephone infrastructure to facilitate high speed data connections.

5.2.3. Wireless Design Option - WiMAX

Fixed wireless as the backbone network- WiMax (Worldwide Interoperability for Microwave Access), WiMAX technology is based on the IEEE 802.16 standard (also called Broadband Wireless Access). The name "WiMAX" was created by the WiMAX Forum which was formed in June 2001 to promote conformity and interoperability of the standard. WiMAX is capable of delivering last mile wireless broadband access as an alternative to cable and DSL. In the USA, the 3650-3700 MHz band has been opened for terrestrial wireless broadband operations.

No consumer devices will operate in this band which means there is a low likelihood of interference. In addition, the license holders are obligated to provide location information to the FCC so potential interference can be solved through cooperation.

5.2.4. Wireless Design Option - Wi-Fi Mesh

A type of Wireless Access network, wireless mesh networks consist of many radio nodes organized in a mesh topology with clients, routers and gateways. The Mesh architecture allows for multiple redundant communication pathways for built-in redundancy.

It is self-organizing and capable of automatically rerouting around failures, providing resiliency and reliability for mission critical communications. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes.

IBI Group is currently in process of obtain budgetary quotes from different vendors. One example would be the wireless mesh system from Tropos network.

5.3. Budgetary Estimate

This section provides a high level budgetary estimate for all the above mentioned technologies. Please note, the assumption used in prepare the cost estimate is that the existing communication infrastructure is in good condition, and useable. The next step is to conduct the necessary field investigation and testing to confirm this assumption, specifically:

- Costs presented are only for the 53 Smart Corridor signalized intersections.
- It is strongly recommended to conduct a fiber audit in the region before deploying any new fiber or reusing existing fiber in order to ensure the availability of fiber strands for the project.
- An audit of the existing copper field installation is required to confirm the performance of the existing system, and that the new system can be constructed without negatively impacting the existing system.
- A Radio Frequency (RF) site survey should be conducted. A site survey will be required as a first step in the deployment of a wireless network in the project area in order to ensure desired operation. In a Wireless network, issues like multi-path distortion, hidden node etc. can arise which can prevent the RF signal from reaching all signals of the desired intersections. The number of proposed base stations throughout the smart corridors may increase depending upon the RF coverage.

5.3.1. Fiber Deployment

As per the available maps, there is an existing fiber network in the City of Tumwater. Assuming availability of 2 fiber strands for this development, only 3 out of the 12 signals will require new fiber installed. For the cities of Olympia and Lacey it is assumed that no fiber infrastructure exists and a complete fiber deployment would be required.

JURISDICTION	TOTAL NUMBER OF INTERSEC-TIONS WHICH REQUIRE FIBER CONNECTIVITY	DISTANCE BETWEEN THE INTERSECTIONS (MILES)	DISTANCE BETWEEN THE CITY HALL AND NEAREST INTERSECTION (MILES)	TOTAL DISTANCE (MILES)
Olympia	36	7.51	0.06	7.57
Lacey	16	4.13	0.25	4.38
Tumwater	3	3.57	0.15	1.02

Exhibit H-11: Fiber Deployment by Jurisdiction

The remainder of this section provides a budgetary quote for each of the three jurisdictions of Olympia, Lacey, and Tumwater for the various communication system options.

The cost of deploying new deep buried fiber in the three jurisdictions is presented in *Exhibit H-12* , *Exhibit H-13* . *Exhibit H-14* .

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
32 mm HDPE duct	foot	$2.00	39970	$79,940.00	7.51 miles of fiber
Fiber optic cable 48 strands (buried)	foot	$4.00	43967	$175,868.00	10% contingency
Splice Enclosures & Termination	each	$2,500.00	37	$92,500.00	1 splice per intersection +1 at city hall
Fiber Termination Panel	each	$200.00	37	$7,400.00	This is based on 1-6 port population
Optical Fiber Drop Cables (6 strands)	foot	$2.00	5550	$11,100.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch	each	$750.00	37	$27,750.00	1 per cabinet +1 at city hall
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	each	$1,950.00	37	$72,150.00	vaults for direct burial
Fiber patch cords	foot	$14.00	37	$518.00	connect FTP to switch
			Material Cost	**$467,226.00**	
INSTALLATION COST					
Asphalt Cutting/removal	foot	$1.00	39970	$39,970.00	
Trenching, conduit install, excavation, backfill, material	foot	$22.00	39970	$879,340.00	
Restoration	cubic feet	$1.00	119910	$119,910.00	assuming 1' wide and 3' deep reusing native soil and compacting. This cost will be higher if a different restoration technique is used
			Installation Cost	**$1,039,220.00**	
			TOTAL	**$1,506,446.00**	

Exhibit H-12: Olympia Cost of Deploying Fiber Network: Deep Buried Installation

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
32 mm HDPE duct	foot	$2.00	23127	$46,254.00	4.38 miles of fiber
Fiber optic cable 48 strands (buried)	foot	$4.00		$101,760.00	10% contingency
Splice Enclosures & Termination	each	$2,500.00	25440	$42,500.00	1 splice per intersection +1 at city hall
Fiber Termination Panel	each	$200.00	17	$3,400.00	This is based on 1-6 port population
Optical Fiber Drop Cables (6 strands)	foot	$2.00	17	$5,100.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch	each	$750.00		$12,750.00	1 per cabinet +1 at city hall
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep	each	$1,950.00	2550	$33,150.00	vaults for direct burial
Fiber patch cords	foot	$14.00	17	$238.00	connect FTP to switch
			Material Cost	**$245,152.00**	
INSTALLATION COST					
Asphalt Cutting/removal	foot	$1.00	23127	$23,127.00	
Trenching, conduit install, excavation, backfill, material	foot	$22.00	23127	$508,794.00	
Restoration	cubic feet	$1.00	69381	$69,381.00	assuming 1' wide and 3' deep. reusing native soil and compacting. This cost will be higher if a different restoration technique is used
			Installation Cost	**$601,302.00**	
			TOTAL	**$846,454.00**	

Exhibit H-13: Lacey Cost of Deploying Fiber Network: Deep Buried Installation

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
32 mm HDPE duct	foot	$2.00	5386	$10,772.00	1.02 miles of fiber
Fiber optic cable 48 strands (buried)	foot	$4.00	5925	$23,700.00	10% contingency
Splice Enclosures & Termination	each	$2,500.00	4	$10,000.00	1 splice per intersection + 1 at Tumwater City Hall
Fiber Termination Panel	each	$200.00	4	$800.00	This is based on 1-6 port population
Optical Fiber Drop Cables (6 strands)	foot	$2.00	600	$1,200.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch	each	$750.00	13	$9,750.00	1 per cabinet / intersection + 1 at Tumwater City Hall
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep	each	$1,950.00	4	$7,800.00	vaults for direct burial
Fiber patch cords	foot	$14.00	13	$182.00	connect FTP to switch
			Material Cost	**$64,204.00**	
INSTALLATION COST					
Asphalt Cutting/removal	foot	$1.00	5386	$5,386.00	vaults for direct burial
Trenching, conduit install, excavation, backfill, material	foot	$22.00	5386	$118,492.00	connect FTP to switch
Restoration	cubic feet	$1.00	16158	$16,158.00	assuming 1' wide and 3' deep. reusing native soil and compacting. This cost will be higher if a different restoration technique is used
			Installation Cost	**$140,036.00**	
			TOTAL	**$204,240.00**	

Exhibit H-14: Tumwater Cost of Deploying Fiber Network: Deep Buried Installation

The cost of deploying new aerial fiber in the three jurisdictions is presented in *Exhibit H-15* , *Exhibit H-16* , and *Exhibit H-17* .

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Fiber optic cable 48 strands (buried)	foot	$4.00	43967	$87,934.00	10% contingency
Splice Enclosures & Termination	each	$2,500.00	36	$90,000.00	1 splice per intersection
Fiber Termination Panel	each	$200.00	36	$7,200.00	
Optical Fiber Drop Cables (6 strands)	foot	$2.00	5400	$10,800.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch (Garretcom)	each	$750.00	36	$27,000.00	
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	each	$1,950.00	36	$70,200.00	
Fiber patch cords	foot	$14.00	36	$504.00	connect FTP to switch
			Material Cost	**$293,638.00**	
INSTALLATION COST					
Additional cost for aerial strands and installation	foot	$8.00	39970	$319,760.00	Aerial strands + pole attachment hardware; supply and install
			Installation Cost	**$319,760.00**	
Yearly cost of leasing poles for aerial installation	each	$15.00	400	$6,000.00	assuming 1 pole per 100 feet
			Operational Cost	**$6,000.00**	
			Total fiber backbone cost (aerial install)	**$619,398.00**	

Exhibit H-15: Olympia Cost of Deploying Fiber Network: Aerial Installation

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Fiber optic cable 48 strands (buried)	foot	$4.00	25440	$50,880.00	10% contingency
Splice Enclosures & Termination	each	$2,500.00	16	$40,000.00	1 splice per intersection
Fiber Termination Panel	each	$200.00	16	$3,200.00	
Optical Fiber Drop Cables (6 strands)	foot	$2.00	2400	$4,800.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch (Garretcom)	each	$750.00	16	$12,000.00	
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	each	$1,950.00	16	$31,200.00	
Fiber patch cords	foot	$14.00	16	$224.00	connect FTP to switch
			Material Cost	**$142,304.00**	
INSTALLATION COST					
Additional cost for aerial strands and installation	foot	$8.00	23127	$319,760.00	Aerial strands + pole attachment hardware; supply and install
			Installation Cost	**$200,000.00**	
Yearly cost of leasing poles for aerial installation	each	$15.00	232	$3,480.00	assuming 1 pole per 100 feet
			Operational Cost	**$3,480.00**	
			Total fiber backbone cost (aerial install)	**$345,784.00**	

Exhibit H-16: Lacey Cost of Deploying Fiber Network: Aerial Installation

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Fiber optic cable 48 strands (buried)	foot	$4.00	5925	$11,850.00	10% contingency
Splice Enclosures & Termination	each	$2,500.00	3	$7,500.00	1 splice per intersection
Fiber Termination Panel	each	$200.00	3	$600.00	
Optical Fiber Drop Cables (6 strands)	foot	$2.00	450	$900.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch (Garretcom)	each	$750.00	3	$2,250.00	
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	each	$1,950.00	3	$5,850.00	
Fiber patch cords	foot	$14.00	3	$42.00	connect FTP to switch
			Material Cost	**$28,992.00**	
INSTALLATION COST					
Additional cost for aerial strands and installation	foot	$8.00	5386	$43,088.00	Aerial strands + pole attachment hardware; supply and install
			Installation Cost	**$200,000.00**	
Yearly cost of leasing poles for aerial installation	each	$15.00	54	$810.00	assuming 1 pole per 100 feet
			Operational Cost	**$810.00**	
			Total fiber backbone cost (aerial install)	**$72,890.00**	

Exhibit H-17: Tumwater Cost of Deploying Fiber Network: Aerial Installation

The cost of deploying new buried fiber using a micro-trench installation technique is presented for all three jurisdictions in *Exhibit H-18* , *Exhibit H-19* , and *Exhibit H-20* .

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Vertical Deflecting Conduit VDC4	foot	$3.00	39970	$119,910.00	
48 strand 4mm vertical inlaid fiber VIF	foot	$1.00	43967	$43,967.00	10% contingency
Flexible Transition Tubing FTT (1/2 “)	foot	$1.00	1110	$1,110.00	estimated 30 feet per location + 30 feet for city hall
VDC4 to FTT clamp	each	$27.71	74	$2,050.54	1 per transition from VDC so 1 per location + 1 for city hall
9” can, Access Nodes	each	$367.00	160	$58,720.00	placed 250-300 feet apart to allow for future pulling of cable in empty channels(250 feet apart for this calc)
splice enclosures	each	$59.00	37	$2,183.00	1 per location + 1 for city hall
VDC4 seam cover kit	each	$1.26	134	$168.84	1 per 300 ft of VDC
Ruggedized Switch (Garretcom)	each	$750.00	37	$27,750.00	1 per location + 1 for city hall
			Material Cost	**$28,992.00**	
INSTALLATION COST					
Installation/Labor Cost	foot	$20.00	39970	$799,400.00	Assuming $20/foot
			Installation Cost	**$799,400.00**	
Total fiber backbone cost-teraspan shallow burial				**$1,055,259.38**	

Exhibit H-18: Olympia Cost of Deploying Fiber Network: Micro-Trench Installation

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Vertical Deflecting Conduit VDC4	foot	$3.00	23127	$69,381.00	
48 strand 4mm vertical inlaid fiber VIF	foot	$1.00	25440	$25,440.00	10% contingency
Flexible Transition Tubing FTT (1/2 “)	foot	$1.00	510	$510.00	estimated 30 feet per location + 30 feet for city hall
VDC4 to FTT clamp	each	$27.71	34	$942.14	1 per transition from VDC so 1 per location + 1 for city hall
9” can, Access Nodes	each	$367.00	93	$34,131.00	placed 250-300 feet apart to allow for future pulling of cable in empty channels(250 feet apart for this calc)
splice enclosures	each	$59.00	17	$1,003.00	1 per location + 1 for city hall
VDC4 seam cover kit	each	$1.26	78	$98.28	1 per 300 ft of VDC
Ruggedized Switch (Garretcom)	each	$750.00	17	$12,750.00	1 per location + 1 for city hall
			Material Cost	**$144,255.42**	
INSTALLATION COST					
Installation/Labor Cost	foot	$20.00	23127	$462,540.00	Assuming $20/foot
			Installation Cost	**$462,540.00**	
Total fiber backbone cost-teraspan shallow burial				**$606,795.42**	

Exhibit H-19: Lacey Cost of Deploying Fiber Network: Micro-Trench Installation

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Vertical Deflecting Conduit VDC4	foot	$3.00	5386	$16,158.00	
48 strand 4mm vertical inlaid fiber VIF	foot	$1.00	5925	$5,925.00	10% contingency
Flexible Transition Tubing FTT (1/2 “)	foot	$1.00	120	$120.00	estimated 30 feet per location + 30 feet for city hall
VDC4 to FTT clamp	each	$27.71	8	$221.68	1 per transition from VDC so 1 per location + 1 for city hall
9” can, Access Nodes	each	$367.00	22	$8,074.00	placed 250-300 feet apart to allow for future pulling of cable in empty channels (250 feet apart for this calc)
splice enclosures	each	$59.00	4	$236.00	1 per location + 1 for city hall
VDC4 seam cover kit	each	$1.26	18	$22.68	1 per 300 ft of VDC
Ruggedized Switch (Garretcom)	each	$750.00	4	$3,000.00	1 per location + 1 for city hall
			Material Cost	**$33,757.36**	
INSTALLATION COST					
Installation/Labor Cost	foot	$20.00	5386	$107,720.00	Assuming $20/foot
			Installation Cost	**$107,720.00**	
Total fiber backbone cost-teraspan shallow burial				**$141,477.36**	

Exhibit H-20: Tumwater Cost of Deploying Fiber Network: Micro-Trench Installation

5.3.2. Copper DSL Deployment

The cost of deploying a DSL-copper communication network in the three jurisdictions is presented on *Exhibit H-21* , *Exhibit H-22* , and *Exhibit H-23* . An important assumption is that the existing copper infrastructure is installed, and useable. This means that the existing copper plant, which is currently being used for signal control, and be sub-divided and reallocated to only the project signalized intersections.

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
RS930L base EoVDSL switch	each	$969.00	30	$29,070.00	1 for each intersection + 1 at Olympia City Hall
2 VDSL ports	each	$850.00	30	$25,500.00	price is for a standard reach VDSL port (<1.5 miles)
DIN Rail	each	$30.00	30	$900.00	
			Material Cost	**$55,470.00**	
INSTALLATION COST					
Installation/Labor Cost		$150.00	30	$4,500.00	Assuming existing copper infrastructure is installed and in place. $150 for switch installation and configuration.
			Installation Cost	**$4,500.00**	
			Total Copper DSL	**$59,970.00**	

Exhibit H-21: Olympia Cost of Deploying Copper DSL Network

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
RS930L base EoVDSL switch	each	$969.00	14	$12,566.00	1 for each intersection + 1 at Olympia City Hall
2 VDSL ports	each	$850.00	14	$11,900.00	price is for a standard reach VDSL port (<1.5 miles)
DIN Rail	each	$30.00	14	$420.00	
			Material Cost	**$25,886.00**	
INSTALLATION COST					
Installation/Labor Cost		$150.00	14	$2,100.00	Assuming existing copper infrastructure is installed and in place. $150 for switch installation and configuration.
			Installation Cost	**$2,100.00**	
			Total Copper DSL	**$27,986.00**	

Exhibit H-22: Lacey Cost of Deploying Copper DSL Network

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
RS930L base EoVDSL switch	each	$969.00	12	$11,628.00	1 for each intersection + 1 at Tumwater City Hall
2 VDSL ports	each	$850.00	12	$10,200.00	price is for a standard reach VDSL port (<1.5 miles)
DIN Rail	each	$30.00	12	$360.00	
			Material Cost	**$22,188.00**	
INSTALLATION COST					
Installation/Labor Cost		$150.00	12	$1,800.00	Assuming existing copper infrastructure is installed and in place. $150 for switch installation and configuration.
			Installation Cost	**$1,800.00**	
			Total Copper DSL	**$23,988.00**	

Exhibit H-23: Tumwater Cost of Deploying Copper DSL Network

5.3.3. Wireless Deployment: WiFi Mesh

The cost of deploying a WiFi mesh wireless solution in the three jurisdictions is presented on *Exhibit H-24* , *Exhibit H-25* , and *Exhibit H-26* .

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Small Form Factor Outdoor Base Station	each	$5,995.00	2	$11,990.00	
Single Port 802.3 Power over Ethernet Injector	each	$250.00	2	$500.00	
ANT Sector BST	each	$250.00	4	$1,000.00	
Outdoor Cat5 Cable	foot	$30.00	62	$1,860.00	50 feet long. Required at each subscriber unit including 1 at city hall, and at each base station
High Gain Outdoor Subscriber Unit	each	$850.00	30	$25,500.00	
Single AC Power cord	each	$5.00	2	$10.00	
Mounting Kit	each	$1,200.00	2	$2,400.00	
Lightning Protector	each	$250.00	2	$500.00	
			Material Cost	**$43,760.00**	
INSTALLATION COST					
Per base station		$10,000	2	$20,000.00	Assumption antenna engineering cost
Per subscriber unit		$2,500	30	$75,000.00	
			Installation Cost	**$95,000.00**	
			Total WiFi Mesh	**$138,760.00**	

Exhibit H-24: Olympia Cost of Deploying Wireless WiFi Mesh Network

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Small Form Factor Outdoor Base Station	each	$5,995.00	2	$11,990.00	
Single Port 802.3 Power over Ethernet Injector	each	$250.00	2	$500.00	
ANT Sector BST	each	$250.00	4	$1,000.00	
Outdoor Cat5 Cable	foot	$30.00	30	$900.00	50 feet long. Required at each subscriber unit including 1 at city hall, and at each base station
High Gain Outdoor Subscriber Unit	each	$850.00	14	$11,900.00	
Single AC Power cord	each	$5.00	2	$10.00	
Mounting Kit	each	$1,200.00	2	$2,400.00	
Lightning Protector	each	$250.00	2	$500.00	
			Material Cost	**$29,200.00**	
INSTALLATION COST					
Per base station		$10,000	2	$20,000.00	Assumption antenna engineering cost
Per subscriber unit		$2,500	30	$35,000.00	
			Installation Cost	**$55,000.00**	
			Total WiFi Mesh	**$84,200.00**	

Exhibit H-25: Lacey Cost of Deploying Wireless WiFi Mesh Network

MATERIAL COST					
Work/Item Description	**Unit**	**Unit Price**	**Qty**	**Total Price**	**Comment**
Small Form Factor Outdoor Base Station	each	$5,995.00	2	$11,990.00	
Single Port 802.3 Power over Ethernet Injector	each	$250.00	2	$500.00	
ANT Sector BST	each	$250.00	4	$1,000.00	
Outdoor Cat5 Cable	foot	$30.00	26	$780.00	50 feet long. Required at each subscriber unit including 1 at city hall, and at each base station
High Gain Outdoor Subscriber Unit	each	$850.00	12	$10,200.00	
Single AC Power cord	each	$5.00	2	$10.00	
Mounting Kit	each	$1,200.00	2	$2,400.00	
Lightning Protector	each	$250.00	2	$500.00	
			Material Cost	**$27,380.00**	
INSTALLATION COST					
Per base station		$10,000	2	$20,000.00	Assumption antenna engineering cost
Per subscriber unit		$2,500	30	$30,000.00	
			Installation Cost	**$50,000.00**	
			Total WiFi Mesh	**$77,380.00**	

Exhibit H-26: Tumwater Cost of Deploying Wireless WiFi Mesh Network

5.3.4. Communication System Budgetary Summary

Exhibit H-27 summarizes the communication system supply and installation cost for the above systems, for each agency.

AGENCY	COSTS OF DEPLOYING A COMMUNICATION NETWORK				
	Fiber (buried)	**Fiber (aerial)**	**Fiber (micro- trench)**	**Copper (DSL solution)**	**Wireless (WiMax)**
Olympia	$1,408,292	$560,822	$1,003,163	$59,970	$138,760
Lacey	$639,416	$314,863	$454,396	$27,986	$84,200
Tumwater	$204,240	$72,890	$141,477	$23,988	$77,380
	$2,251,948	**$948,575**	**$1,599,036**	**$111,944**	**$300,340**

Exhibit H-27: Communication System Supply and Installation Budgetary Estimate

6. Transit Management System

6.1. Existing System

The existing Opticom™ IR system is used for Emergency Signal Pre-emption (ESP). Depending on the configuration of this system, it may be suitable for TSP. In many EVP applications one 721 Opticom™ detector is used for two intersection approaches. Our preferred TSP layout is to use a single 721 detector per TSP approach, with both turrets facing upstream. This layout also requires additional Opticom™ phase selectors to support the additional "channels" of detection required for TSP.

The existing ACS CAD/AVL system requires central software modifications to support "Integrated" or "Conditional" TSP based upon schedule adherence. Unconditional TSP does not require upgrade of the CAD/AVL System.

6.2. Migration Options

The purpose of enhancing the existing transit management system is to provide transit vehicle detection for TSP.

The specific technologies that may be enhanced through this project include:

- Schedule and runcutting system (A1);
- CAD/AVL system (A2);
- Vehicle Logic Unit (VLU) (A3);
- On-vehicle Transit Vehicle Detection System (B1); and
- Roadside Transit Vehicle Detection System (B2).

There are primarily two transit vehicle detection technologies available for implementation, which include:

- Opticom™ infrared (IR) detection; and
- Unlicensed radio detection (e.g. Opticom™ GPS, EMTRAC).

It should be noted that a transponder-based system could also be used. The transponder-based system has not been investigated for this project. In general a transponder-based system is cost effective in installations with only a few signalized intersections. The on-vehicle equipment is relatively inexpensive (approximately $500 per vehicle). However, the roadside equipment requires the installation of a reader upstream from the signalized intersection, which can communicate the request for priority to the signalized intersection.

In larger signalized intersection installations the cost associated to install the roadside equipment, and the installation logistics (i.e. coordinating with utilities), generally make this approach to TSP less desirable in comparison to the other technologies mentioned above.

Each of the above technologies could be implemented in isolation to provide unconditional transit signal priority. It should be noted that some radio systems can provide conditional signal priority.

Integrating these technologies with the CAD/AVL and schedule and runcutting system can provide conditional TSP. The following identifies example projects completed by ACS, using the above technologies:

- Escondido, CA – interfaced with Opticom™ IR. The onboard ACS VLU activates TSP when off-schedule above a configurable threshold (3 minutes), and deactivates TSP when off- schedule below a configurable threshold (2 minutes). All TSP trigger points, check-in (CI) and check-out (CO) are programmed in the ACS VLU.
- Brampton, ON, Canada – EMTRAC radio installed on each vehicle. Each bus activates a relay output when off-schedule adherence above a configurable threshold (3 minutes), and deactivates the relay when off-schedule below a configurable threshold (2 minutes). All TSP trigger points, CI, and CO are programmed in the EMTRAC units.

- Foothill Transit, CA – The TSP protocol is based on the LA Regional TSP protocol using WLAN. The VLU is connected (and using) the same WLAN antenna used at the garages for bulk download of data from the vehicle at the end of the day. ACS has completed the development and testing on-vehicle, but they are still working on the intersection side of the equation. It should be noted that the WLAN antenna is being used. In our experience a wireless router is required on the transit vehicle to facilitate TSP. WiFi is a "nomadic" protocol, that is not inherently designed for "roaming" applications. Systems such as the Novax TransPod system use a wireless router (e.g. Tropos) on-vehicle.

6.3. Budgetary Estimate

The following migration strategies are considered viable for this project:

1. Standalone Opticom™ IR – this option performs unconditional TSP, and requires the addition of Opticom™ emitters on the transit vehicle. This option is divided into two sub- scenarios.
   - In the first sub-scenario the existing Opticom™ IR roadside equipment can support TSP; and
   - In the second sub-scenario the existing Opticom™ IR roadside equipment must be updated to support TSP.
2. Standalone Unlicensed Radio – this option performs unconditional TSP. It requires the addition of a new onboard VLU to control the radio, and associated roadside equipment;
3. Integrated Opticom™ IR – this option integrates the existing ACS VLU with the Opticom™ IR system;
4. Integrated Unlicensed Radio – this option integrates the existing ACS VLU with a radio- based system. This option includes systems such as Opticom™ GPS or EMTRAC, which are interfaced to the ACS VLU.

   It should also be noted that WiFi is an unlicensed radio technology that could be used for this project. The cost analysis of a WiFi-based system has not been prepared. WiFi systems require the development of a continuous wireless network throughout the TSP enabled project area. In our experience, this network has been cost-prohibitive for TSP. If the wireless network is used in conjunction with the traffic signal control system network, then the technology can prove viable. The on-vehicle costs for a WiFi based system are similar to the other technologies under consideration.

Exhibit H-28 presents a budgetary estimate to implement the above options. The cost to implement a transit vehicle detection system ranges from approximately $162,000 to $1,239,000.

ITEM NO.	ITEM DESCRIP-TION	QTY	1.1 STANDALONE OPTICOM IR		1.2 STANDALONE OPTICOM IR		2. STAND ALONE UNLICENSED RADIO		3.1 INTEGRATED OPTICOM IR		3.2 INTEGRATED OPTICOM IR		4. INTEGRATED UNLICENSED RADIO	
			Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost	Unit Cost ($)	Total Cost
Transit Vehicle Detection Central Software (new)														
S.T.1	Supply Central Software	1	$0	$0	$0	$0	$10,000	$10,000	$0	$0	$0	$0	$10,000	$10,000
I.T.1	Install Central Software	1	$0	$0	$0	$0	$1,000	$1,000	$0	$0	$0	$0	$1,000	$1,000
On-Vehicle Transit Vehicle Detection (B1)														
S.T.2	Supply	60	$2,200	$132,000	$2,200	$132,000	$6,000	$360,000	$2,200	$132,000	$2,200	$132,000	$6,000	$360,000
I.T.2	Installation	60	$500	$30,000	$500	$30,000	$500	$30,000	$500	$30,000	$500	$30,000	$500	$30,000
Roadside Transit Vehicle Detection (B2)														
S.T.3	Supply	61	$0	$0	$6,000	$366,000	$6,000	$366,000	$0	$0	$6,000	$366,000	$6,000	$366,000
I.T.3	Installation	61	$0	$0	$1,000	$61,000	$500	$30,500	$0	$0	$1,000	$61,000	$500	$30,500
ACS Central Transit M anagement System (A2)														
S.A.1	Supply Central Software	1	$0	$0	$0	$0	$0	$0	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000
I.A.1	Install Central Software	1	$0	$0	$0	$0	$0	$0	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
On-Vehicle ACS VLU (A3)														
S.A.2	Supply	60	$0	$0	$0	$0	$0	$0	$500	$30,000	$500	$30,000	$500	$30,000
I.A.2	Installation	60	$0	$0	$0	$0	$0	$0	$600	$36,000	$600	$36,000	$600	$36,000
		Total		**$162,000**		**$589,000**		**$797,500**		**$603,000**		**$1,030,000**		**$1,238,500**

Exhibit H-28: Transit Vehicle Detection Budgetary Estimate

7. Smart Corridors Implementation Alternatives

This section contains preliminary planning analysis and is provided for background only. See current project design documentation for updated information.

7.1. Summary of Proposed Alternatives

This section presents three Smart Corridors deployment 'packages' representing the low, medium, and high range cost alternatives, as a basis for discussion with the Regional Traffic Operations Group on selecting a preferred technology approach and project definition.

STRATEGY	DESIGN OBJECTIVE	KEY FEATURES	ESTIMATED COST FOR SMART CORRIDORS INTERSECTIONS*
Alternative 1: **Leverage Existing Infrastructure** (Low Range)	Maximize the use of existing equipment cabinet and communications infrastructure.	• Low-cost controller upgrade or replacement • Upgrade existing Olympia and QuicNet TSCS • Replace Lacey/Tumwater and TSCS • Standalone IR transit detection • Copper DSL communications	$1.1 million*
Alternative 2: Performance Upgrades (Mid-Range)	Strategic replacement of key system components to maximize performance at a mid-range price point.	• Replace controllers only • Upgrade existing OlympiaQuicNet TSCS • Replace Lacey/TumwaterTSCS • Standalone unlicensed radio transit detection • Wireless communications;fiber in Tumwater	$2.1 million*
Alternative 3: **Rebuild and Replace** (High Range)	Replace and upgrade existing controller, cabinet, and communications infrastructure to maximize functionality and service life.	• Replace controller cabinet assemblies • Replace Olympia, Lacey, andTumwater TSCS • Integrated unlicensed radio transit detection • Buried fiber optic communications	$5.5. million*

*plus contingency, soft costs, and off-corridor interconnected signal upgrades required.

Exhibit H-29: Summary of Smart Corridors Implementation Alternatives

The following assumptions and limitations should be noted:

- Cost estimates assume installation at only the 53 Smart Corridor and 'Spur' signalized intersections. Additional interconnected signals located off the corridor will result in increased costs.
- Additional analysis is necessary completed to validate the wireless communications option, the feasibility of using the existing copper and fiber networks (e.g., based on their condition). Also, a contingency, and engineering design fees have not been added to the costs.

7.2. Alternative 1: Leverage Existing Infrastructure

This deployment strategy makes use of the existing infrastructure to the extent possible.

The Low Cost Deployment Strategy includes:

- Local Controller : Strategy 1 (Maximize Use of Existing Controllers) - $116,850
- Traffic Signal Control System Upgrades (Upgrade Olympia QuicNet; Replace Lacey and Tumwater) - $780,000
- Transit Vehicle Detection – Standalone IR - $162,000
- Communication System – Copper DSL Solution - $52,000. Note that in the low cost controller strategy there is no communication system cost associated with the City of Olympia. The QuicNet system will communicate with the local controller using the existing communication network

The overall cost estimate for this option is approximately $994,000 not including contingency. Also, it is more likely that the existing copper communications network will not be suitable. As a result, a wireless network would be implemented in the City of Lacey and Tumwater, which increases the strategy cost $109,500 to $1,103,500.

7.3. Alternative 2: Performance Upgrades

This alternative includes selective upgrades of equipment to maximize functionality and performance, while still leveraging existing equipment and communications infrastructure to the extent possible.

Alternative 2 includes:

- Local Controller: Strategy 2 (Replace Controllers Only) - $205,300
- Traffic Signal Control System Upgrades (Upgrade Olympia QuicNet; Replace Lacey and Tumwater) - $780,000
- Transit Vehicle Detection: Strategy 2 (Standalone Unlicensed Radio) - $797,500
- Communication System – The City of Tumwater has an extensive fiber communications network which will be extended at a cost of $73,000. The City of Olympia and Lacey communication network will be constructed using wireless systems at a cost of $223,000. The total communications cost is $296,000

The overall cost estimate for this option is approximately $2,079,000, not including contingency.

7.4. Alternative 3: Rebuild and Replace

This alternative includes upgrade of complete controller cabinet assemblies and use of buried fiber optic cable. This alternative represents an 'upper bound' cost option that maximizes system replacement and upgrades.

Alternative 3 includes:

- Local Controller: Strategy 3 (Replace Controller Cabinet Assembly) - $926,000
- Central Traffic Signal Control System Upgrades - $1,125,000 (Replace Olympia, Lacey, and Tumwater; assumes the new McCain central software is released and comparable in cost to Econolite Centracs)

- Transit Vehicle Detection – Integrated Unlicensed Radio - $1,238,500
- Communication System – Buried Fiber - $2,252,000

The overall cost estimate for this option is approximately $5,542,000, not including contingency.

7.5. Budgetary Estimates for Key Cost Items

The following table provides a breakdown of the key cost elements that have been bundles into the three alternatives presented above, including a breakdown by operating agency.

The table also includes the extended cost for traffic controllers over the 25 intersections known to be interconnected with Smart Corridors intersections. Note that including these additional interconnected intersections will trigger additional communications infrastructure costs as well.

As with the estimates presented in the previous pages, these figures exclude contingency and soft costs.

CONTROLLER	SMART CORRIDOR			ENTIRE PROJECT AREA		
	Strategy 1 - Low Cost	Strategy 2 - Controllers	Strategy 3 - Controller Cabinet Assembly	Strategy 1 - Low Cost	Strategy 2 - Controllers	Strategy 3 - Controller Cabinet Assembly
Olympia	$18,850	$107,300	$580,000	$24,050	$136,900	$740,000
Lacey	$31,500	$31,500	$140,000	$108,000	$108,000	$480,000
Thurston County	$18,000	$18,000	$80,000	$18,000	$18,000	$80,000
WSDOT	$9,000	$9,000	$40,000	$9,000	$9,000	$40,000
Tumwater	$39,500	$39,500	$86,000	$39,500	$39,500	$86,000
Total	**$116,850**	**$205,300**	**$926,000**	**$198,550**	**$311,400**	**$1,426,000**
TSCS CENTRAL SOFTWARE						
Olympia	$30,000					
Lacey	$375,000					
Tumwater	$375,000					
Total	**$780,000**					
TRANSIT VEHICLE DETECTION						
	1.1 Standalone Opticom IR	1.2 Standalone Opticom IR	2. Standalone Unlicensed Radio	3.1 Integrated Opticom IR	3.2 Integrated Opticom IR	4. Integrated Unlicensed Radio
Total	**$162,000**	**$589,000**	**$797,500**	**$603,000**	**$1,030,000**	**$1,238,500**
COMMUNICATION SYSTEM						
	Copper (DSL solution)	Wireless (WiMax)	Fiber (aerial)	Fiber (micro-trench)	Fiber (buried)	
Olympia	$59,970	$138,760	$560,822	$1,003,163	$1,408,292	
Lacey	$27,986	$84,200	$314,863	$454,396	$639,416	
Tumw ater	$23,988	$77,380	$72,890	$141,477	$204,240	
Total	**$111,944**	**$300,340**	**$948,575**	**$1,599,036**	**$2,251,948**	

Exhibit H-30: Budgetary Estimate Summary of Options

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TAB I:

APPENDICES

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Appendix I1:

Detailed Project Cost Information

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Appendix I2:

Traffic Signal Inventory – Reported by Agencies

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Appendix I3:

Summary of Transit Operational Analysis

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Appendix I4:

Responses to WSDOT Systems Engineering (SE) Questionnaire

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Appendix I5:

Contact List of RTOG Members

Appendix 5: Smart Corridors Regional Traffic Operations Group Contact List

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