Thurston Regional Planning Council

SMART CORRIDORS TECHNOLOGY ALTERNATIVES

REPORT

APRIL 2011

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1. OVERVIEW

This document presents technology implementation alternatives for the Thurston Smart Corridors initiative. Candidate technologies include traffic signal coordination and optimization, transit signal priority, 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

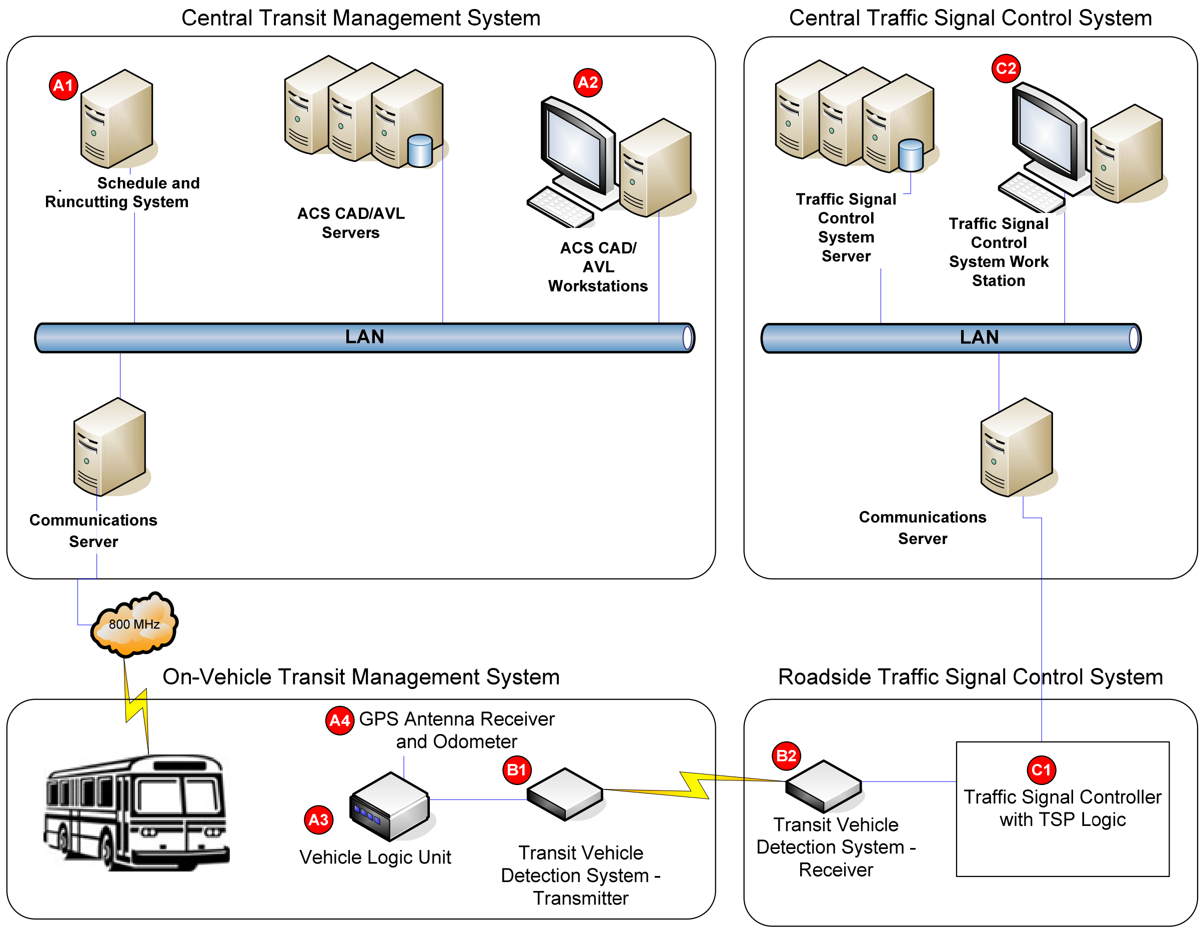
2.1 Component Technology Systems

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)

The various Smart Corridor systems and subsystems are illustrated in Exhibit 2-1 and further described below. The potential system modifications required to support the Smart Corridors project are also identified and highlighted.

Exhibit 2-1: 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) Computer Aided Dispatch (CAD)/ Automatic Vehicle Location (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 above 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 depending, which are compatible with the on-vehicle equipment. 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.*

- **C2 – 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.

2.1 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. The list below was derived from existing information provided by the jurisdictions; additional existing interconnects may exist but have not been field verified.

Exhibit 2-2: Project Signalized Intersections

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**

3. LOCAL INTERSECTION CONTROLLER ALTERNATIVES

This section discusses options and cost estimates for upgrading existing local intersection controllers along the Smart Corridor jurisdictions.

3.1 Existing Controller Inventory and Migration Options

Exhibit 3-1 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.

Exhibit 3-1: Controller Inventory

Owned By	Operated By	Maintained By	Controller	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 Co	Lacey	Lacey	Traconex TMP-390	v4	NEMA "P"	4	
Thurston Co							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**

Based on Exhibit 3-1, 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;
- 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;
- 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;
- 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;
- 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>)	**Strategy 1 – Low Cost**	**Strategy 2 – Controllers**	**Strategy 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 3-2: Smart Corridor Controller Replacement Budgetary Estimate

Item No.	Item Description	Quantity	Strategy 1 - Low Cost		Strategy 2 - Controllers		Strategy 3 - Controller Cabinet Assembly	
			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 3-3: Smart Corridor Controller Replacement Budgetary Estimate by Agency

Item No.	Item Description	Quantity	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
I.C.4	Econolite ASC/3	2	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal				*$ 39,000*		*$ 39,000*		*$ 70,000*
Total				**$ 125,400**		**$ 235,200**		**$1,070,000**

Exhibit 3-4 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.

Exhibit 3-4: Controller Replacement Budgetary Estimate

Item No.	Item Description	Quantity	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 3-5: Controller Replacement Budgetary Estimate by Agency

Item No.	Item Description	Quantity	Strategy 1 - Low		Strategy 2 -		Strategy 3 -	
			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**

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 there 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;
- 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;
- Tumwater and Lacey (including Thurston County and WSDOT): Procure an Econolite Centracs system.

Exhibit 4-1 presents a budgetary estimate for the traffic signal control system central software.

Exhibit 4-1: Central Traffic Signal Control System Budgetary Estimate

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**

As presented in Exhibit 4-1, the central traffic signal control system budgetary estimate is $780,000. However, once the new McCain traffic signal control system is formerly released, the cost of the new system should approach the cost of the Econolite Centracs system ($375,000). On the other hand, 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,
- Washington State DOT, and
- 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 Centre. 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 intersections 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

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 Exhibits 5-1, 5-2, and 5-3.

Exhibit 5-1: 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	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	EA	$ 2,500.00	37	$ 92,500.00	1 splice per intersection+1 at city hall
Fiber Termination Panel	EA	$ 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	EA	$ 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.	EA	$ 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 5-2: 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	23127	$ 46,254.00	4.38 miles of fiber
Fiber optic cable 48 strands (buried)	foot	$ 4.00	25440	$ 101,760.00	10% contingency
Splice Enclosures & Termination	EA	$2,500.00	17	$ 42,500.00	1 splice per intersection+1 at city hall
Fiber Termination Panel	EA	$ 200.00	17	$ 3,400.00	This is based on 1-6 port population
Optical Fiber Drop Cables (6 strands)	foot	$ 2.00	2550	$ 5,100.00	150 feet per intersection; connect splice to FTP
Ruggedized Switch	EA	$ 750.00	17	$ 12,750.00	1 per cabinet +1 at city hall
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	EA	$1,950.00	17	$ 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 5-3: Tumwater 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	EA	$2,500.00	4	$ 10,000.00	1 splice per intersection + 1 at Tumwater City Hall
Fiber Termination Panel	EA	$ 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	EA	$ 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.	EA	$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	
Trenching, conduit install, excavation, backfill, material	foot	$ 22.00	5386	$ 118,492.00	
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**	

The cost of deploying new aerial fiber in the three jurisdictions is presented in Exhibits 5-4, 5-5, and 5-6.

Exhibit 5-4: 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 (aerial)	foot	$ 2.00	43967	$ 87,934.00	10% contingency
Splice Enclosures & Termination	EA	$2,500.00	36	$ 90,000.00	1 splice per intersection
Fiber Termination Panel	EA	$ 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)	EA	$ 750.00	36	$ 27,000.00	
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	EA	$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**	
Operational Cost					
Yearly cost of leasing poles for aerial installation	EA	$ 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 5-5: 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 (aerial)	foot	$ 2.00	25440	$ 50,880.00	10% contingency
Splice Enclosures & Termination	EA	$2,500.00	16	$ 40,000.00	1 splice per intersection
Fiber Termination Panel	EA	$ 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)	EA	$ 750.00	16	$ 12,000.00	
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	EA	$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	$200,000.00	Aerial strands + pole attachment hardware; supply and install
			Installation Cost	**$200,000.00**	
Operational Cost					
Yearly cost of leasing poles for aerial installation	EA	$ 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 5-6: Tumwater Cost of Deploying Fiber Network: Aerial Installation

Material Cost					
Work/Item Description	**UNIT**	**UNIT PRICE**	**QTY**	**TOTAL PRICE**	**COMMENT**
Fiber optic cable 48 strands (aerial)	foot	$ 2.00	5925	$ 11,850.00	10% contingency
Splice Enclosures & Termination	EA	$ 2,500.00	3	$ 7,500.00	1 splice per intersection
Fiber Termination Panel	EA	$ 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)	EA	$ 750.00	3	$ 2,250.00	
Vault, precast concrete, with concrete cover, 4' x 4' x 4' deep.	EA	$ 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	**$ 43,088.00**	
Operational Cost					
Yearly cost of leasing poles for aerial installation	EA	$ 15.00	54	$ 810.00	assuming 1 pole per 100 feet
			Operational Cost	**$ 810.00**	
			Total fiber backbone cost (aerial install)	**$ 72,890.00**	

The cost of deploying new buried fiber using a micro-trench installation technique is presented for all three jurisdictions in Exhibits 5-7, 5-8, and 5-9.

Exhibit 5-7: 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	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	EA	$ 27.71	74	$ 2,050.54	1 per transition from VDC so 1 per location+ 1 for city hall
9" can, Access Nodes	EA	$ 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	EA	$ 59.00	37	$ 2,183.00	1 per location + 1 for city hall
VDC4 seam cover kit	EA	$ 1.26	134	$ 168.84	1 per 300 ft of VDC
Ruggedized Switch (Garretcom)	EA	$ 750.00	37	$ 27,750.00	1 per location + 1 for city hall
			Material Cost	**$ 255,859.38**	
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 5-8: 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	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		$ 27.71	34	$ 942.14	1 per transition from VDC so 1 per location+ 1 for city hall
9" can, Access Nodes	EA	$ 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	EA	$ 59.00	17	$ 1,003.00	1 per location + 1 for city hall
VDC4 seam cover kit		$ 1.26	78	$ 98.28	1 per 300 ft of VDC
Ruggedized Switch	EA	$ 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 5-9: Tumwater 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		$ 27.71	8	$ 221.68	1 per transition from VDC so 1 per location+ 1 for city hall
9" can, Access Nodes	EA	$ 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	EA	$ 59.00	4	$ 236.00	1 per location + 1 for city hall
VDC4 seam cover kit		$ 1.26	18	$ 22.68	1 per 300 ft of VDC
Ruggedized Switch	EA	$ 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**	

5.3.2 COPPER DSL DEPLOYMENT

The cost of deploying a DSL-copper communication network in the three jurisdictions is presented on Exhibit 5-10, Exhibit 5-11, and Exhibit 5-12. 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.

Exhibit 5-10: 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	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	**$ 59,970.00**	

Exhibit 5-11: 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	14	$ 13,566.00	1 for each intersection + 1 at Lacey 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	**$ 27,986.00**	

Exhibit 5-12: Tumwater 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				**$ 23,988.00**	

5.3.3 WIRELESS DEPLOYMENT: WIFI MESH

The cost of deploying a WiFi mesh wireless solution in the three jurisdictions is presented on Exhibit 5-13, Exhibit 5-14, and Exhibit 5-15.

Exhibit 5-13: 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	EA	$ 5,995.00	2	$ 11,990.00	
Single Port 802.3 Power over Ethernet Injector	EA	$ 250.00	2	$ 500.00	
ANT Sector BST	EA	$ 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	EA	$ 850.00	30	$ 25,500.00	
Single AC Power cord	EA	$ 5.00	2	$ 10.00	
Mounting Kit	EA	$ 1,200.00	2	$ 2,400.00	
Lightning Protector	EA	$ 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	**$ 138,760.00**	

Exhibit 5-14: 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	EA	$ 5,995.00	2	$ 11,990.00	
Single Port 802.3 Power over Ethernet Injector	EA	$ 250.00	2	$ 500.00	
ANT Sector BST	EA	$ 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	EA	$ 850.00	14	$ 11,900.00	
Single AC Power cord	EA	$ 5.00	2	$ 10.00	
Mounting Kit	EA	$ 1,200.00	2	$ 2,400.00	
Lightning Protector	EA	$ 250.00	2	$ 500.00	
Material Cost				**$ 29,200.00**	
Installation Cost					
Per base station		$ 10,000.00	2	$ 20,000.00	Assumption. antenna engineering cost
Per subscriber unit		$ 2,500.00	14	$ 35,000.00	
Installation Cost				**$ 55,000.00**	
Total				**$ 84,200.00**	

Exhibit 5-15: Tumwater 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	EA	$ 5,995.00	2	$ 11,990.00	
Single Port 802.3 Power over Ethernet Injector	EA	$ 250.00	2	$ 500.00	
ANT Sector BST	EA	$ 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	EA	$ 850.00	12	$ 10,200.00	
Single AC Power cord	EA	$ 5.00	2	$ 10.00	
Mounting Kit	EA	$ 1,200.00	2	$ 2,400.00	
Lightning Protector	EA	$ 250.00	2	$ 500.00	
			Material Cost	**$ 27,380.00**	
Installation Cost					
Per base station		$ 10,000.00	2	$ 20,000.00	Assumption. antenna engineering cost
Per subscriber unit		$ 2,500.00	12	$ 30,000.00	
			Installation Cost	**$ 50,000.00**	
			Total	**$ 77,380.00**	

5.3.4 COMMUNICATION SYSTEM BUDGETARY SUMMARY

Exhibit 5-16 summarizes the communication system supply and installation cost for the above systems, for each agency.

Exhibit 5-16: Communication System Supply and Installation Budgetary Estimate

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**

6. TRANSIT MANAGEMENT SYSTEM

6.1 Existing System

The existing Opticom™ IR system is used for Emergency Vehicle Pre-emption (EVP). 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" Transit Signal Priority 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);
- Roadside Transit Vehicle Detection System (B2).

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

- Opticom™ infrared (IR) detection;
- 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.

   - 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 6-1 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 Description	Quantity	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 Management 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 6-1: Transit Vehicle Detection Budgetary Estimate

7. SMART CORRIDORS IMPLEMENTATION ALTERNATIVES

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.

Exhibit 7-1: Summary of Smart Corridors Implementation Alternatives

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 Quicknet TSCS • Replace Lacey/Tumwater 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 Olympia Quicknet TSCS • Replace Lacey/Tumwater TSCS • 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, and Tumwater TSCS • Integrated unlicensed radio transit detection • Buried fiber optic communications	$5.5. million*

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

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 Quicknet; 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 Quicknet; 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 above, these figures exclude contingency and soft costs.

Exhibit 7-2: Budgetary Estimate Summary of Options

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. Stand Alone 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	
Tumwater	$ 23,988	$ 77,380	$ 72,890	$ 141,477	$ 204,240	
Total	**$ 111,944**	**$ 300,340**	**$ 948,575**	**$ 1,599,036**	**$ 2,251,948**	