REQUEST FOR PROPOSALS

CITY OF RENTON
SW 43rd STREET/CARR ROAD/PETROVITSKY ROAD ADAPTIVE SIGNAL CONTROL TECHNOLOGY

Federal Aid No.: HSIP-000S(306)

Proposal Due Date:
March 17, 2016 no later than 4:00 p.m. PST

Optional Pre-Proposal Meeting/Conference Call:
March 8, 2 p.m. PST at Renton City Hall Room 511.

City of Renton

1055 S Grady Way, Renton, WA 98057

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1 Request for Proposal Notice

This Request for Proposal (RFP) is the official notification of signal system services needed for the City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology (ASCT) project. The City of Renton (City) is issuing this RFP to request a proposal from qualified providers of ASCT (Vendor) to provide equipment, software, installation and integration services as described within this document. A proposal submittal indicates that the Vendor desires to be considered for the needed product and services. A proposal submittal does not guarantee that the Vendor will be contracted to perform the service. The City reserves the right to reject all proposals.

The City of Renton in accordance with Title VI of the Civil Rights Act of 1964, 78 Stat. 252, 42 USC 2000d to 2000d-4 and Title 49, Code of Federal Regulations, Department of Transportation, Subtitle A, Office of the Secretary, Part 21, Nondiscrimination in Federally-Assisted Programs of the Department of Transportation issued pursuant to such Act, hereby notifies all bidders that it will affirmatively ensure that in any contract entered into pursuant to this advertisement, disadvantaged business enterprises as defined at 49 CFR Part 26 will be afforded full opportunity to submit bids in response to this invitation and will not be discriminated against on the grounds of race, color, national origin, or sex in consideration for an award.

2 Introduction

The City of Renton is located just south of Seattle in King County. Major highways in and around the city include I-5, I-405, and SR-167.

Renton is home to large business districts such The Landing and a major Boeing plant. Renton also houses a large population of nearly 100,000 people. These residential areas look to commute from Renton to other business centers in the cities of Seattle, Bellevue, and Redmond. Traffic during the peak commuting periods becomes congested due to this high distribution of travelers. The City of Renton has supported other municipalities and agencies to improve this condition with improved transit, signal coordination, and high occupancy toll lanes.

The City of Renton is looking to further improve the network by installing an advanced traffic signal control system on a highly congested arterial that serves SR 167. This arterial (SW 43rd St/Carr Road/Petrovitsky Road) sees significant swings in traffic volumes in the AM and PM peak periods in addition to diversions during SR 167 incidents. An advanced traffic signal control system will better serve residents and businesses with improved traffic operations and safety.

This RFP invites submittals from ASCT Vendors interested in providing an adaptive signal system that meets Renton's requirements and long-term maintenance needs. This document briefly outlines the project, describes the proposal requirements, and presents the required proposal format. Detailed Vendor responsibilities and evaluation criteria are also described. Vendors submitting proposals shall meet all the requirements of this RFP. Submittals must be in the format outlined in this document.

3 Project Description

The SW 43rd St/Carr Road/Petrovitsky Road adaptive project will implement adaptive signal control technology (ASCT) at 13 total intersections in the City of Renton on the SW 43rd St/Carr Road/Petrovitsky Road, East Valley Highway, and SR 515/108th Ave SE corridors. The following list details the 13 intersections for installation of the ASCT. A full map of the project area is shown in figure 1.

- SW 43rd St & Oakesdale Ave SW
- SW 43rd St & Lind Ave S
- SW 43rd St & E Valley Rd
- SW 41st St (SR 167 Southbound Ramps) & E Valley Rd
- SW 43rd St & SR 167 NB Ramps
- SW 43rd St & Talbot Rd S
- SE Carr Rd & 98th Ave S (Smithers Ave)
- SE Carr Rd & 106th Pl SE
- SE Petrovitsky Rd & SR 515 (Benson Dr S) (108th Ave SE)
- SE Petrovitsky Rd & 116th Ave SE
- SE Petrovitsky Rd & 128th Ave SE
- Benson Rd S & SR 515 (Benson Dr S)
- SE 180th St & SR 515 (108th Ave SE)

Renton's existing signal system uses TACTICS (Siemens) for central operations and Eagle M50 (Siemens) controllers running the SEPAC software.

The existing operation and infrastructure of the signal system are described in section 3.1 of the Concept of Operations document. The Concept of Operations document is attached in Appendix A of this RFP document.

The scope of work for the project includes the installation of an adaptive signal system for the project intersections; delivery and configuration of any hardware; licensing for controller and central firmware/software; training for City staff; maintenance, warranty, and technical support for proper operation of the system. The purpose of this project is to identify an upgrade to Renton's existing traffic signal system that would provide reasonable and predictable travel times, improved safety, additional operational functionality, and an improvement in traffic operations over their existing time-of-day signal coordination. The detailed vision, goals and objectives are described in section 3.4 of the Concept of Operations document.

The adaptive signal system shall meet the user operational needs as described in section 4 of the Concept of Operations document. The user-envisioned operation of the adaptive system and the operational and support environment of the adaptive system are described in sections 5, 6 and 7 of the Concept of Operations document. Detailed operational scenarios and operational objectives for each operational scenario are described in section 8 of the Concept of Operations document. The proposed system shall meet the System Requirements as described in Appendix B of this document.

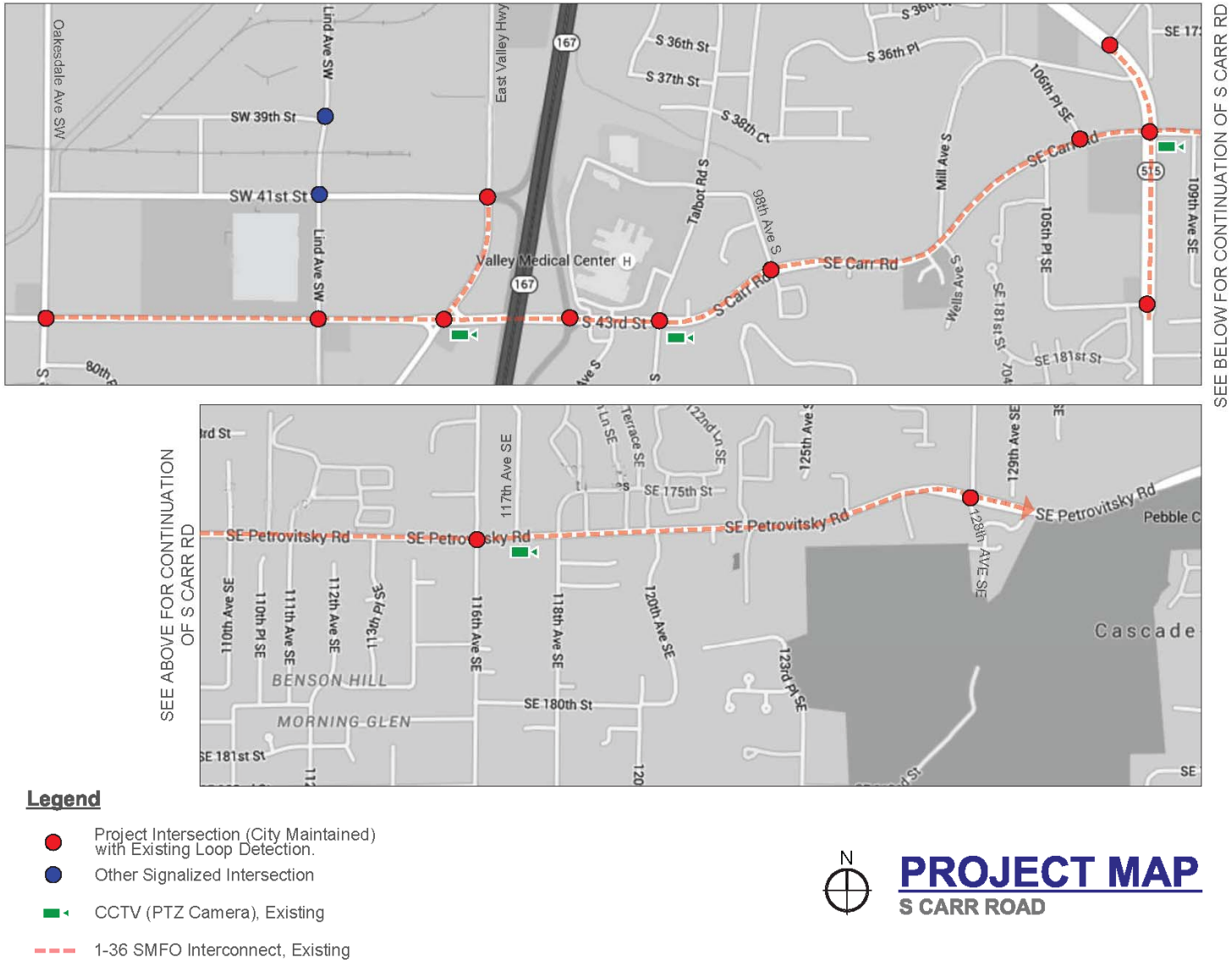

Figure 1 - Project Map

4 Proposal Requirements

This section provides the requirements of the proposal submittals. It summarizes the format of the document; how the response should be structured; and location with due date to submit the proposal.

4.1 General Structure

Proposals shall be submitted on eight and one-half by eleven-inch (8 ½" x 11") paper using one-inch (1") margins with tabs separating the major sections of the proposal, except as described below. All pages must be double-sided; portrait or landscape or mixed orientation is acceptable. Font shall be no less than size 12. The major sections or headings of the proposal are to be submitted in the order noted below:

1. Cover Letter
2. Project Team Structure
3. Staff Qualifications and Experience
4. Project Approach/Work Plan
5. System Requirements
6. Project Schedule
7. Maintenance, Warranty and Support Plan
8. Buy America Requirements
9. Project Cost
10. References
11. Minimum Requirements

Proposals shall provide information in the same order as presented above with the same headings.

The Proposal shall not exceed a length of 30 double-sided pieces of paper, excluding the system requirements matrix, the proposal cover and the required forms.

4.1.1 Cover Letter

The cover letter shall be signed and dated by a person authorized to legally bind the Vendor to a contractual relationship, e.g., the president or executive director or a principal of a corporation; the managing partner if a partnership; or the proprietor if a sole proprietorship. The cover letter shall include the following information about the Vendor and any proposed subcontractors:

- Name, address, principal place of business, contact information of legal entity or individual with whom contract would be written and executed
- Structure of the business entity: legal status of the Vendor (sole proprietorship, partnership, corporation, etc.)
- Location of the facility from which the contract service(s) will be provided
- Identify any current or former City employees employed by or on the Vendor governing board as of the date of the proposal or during the previous twelve (12) months
- Acknowledgement that the Vendor will conform to all terms and conditions set forth in the RFP, unless otherwise agreed to by the City

- Proof of signature authority

4.1.2 Project Team Structure

Provide a description of the proposed project team structure, including any subcontractors. Include the persons whom will be responsible for the installation and ensuring proper operation of the system and service offered. The City expects that the lead proposer will be providing the majority of the services. Provide the experiences the Vendor and the subcontractors (if any) have in the following areas:

- ASCT design and implementation
- ASCT system integration
- ASCT operations and training
- ASCT performance measure collection and reporting
- ASCT maintenance/support

Provide detailed information if the Vendor has had a contract terminated for default in the last five (5) years. Termination for default is defined as notice to stop performance due to the Vendor's non-performance or poor performance. Submit full details of the terms for default, including the other party's name, address, and phone number. The City will evaluate the facts and may, at its sole discretion, reject the proposal on the grounds of the past experience.

4.1.3 Staff Qualifications and Experience

Identify staff members whom will be assigned to the potential contract, including subcontractors, indicating the responsibilities and qualifications of such personnel. Provide resumes of each staff member. Include information on the individual's skills and experiences in design, deployment, integration, operations, and maintenance of adaptive signal control technology systems; significant accomplishments; and any other pertinent information. The City requires that staff identified in Vendor's proposal will actually perform the assigned work. Any staff substitution must have the prior approval of the City.

4.1.4 Project Approach/Work Plan

Provide a complete description of the proposed approach and methodology for the project. This section should express the Vendor's understanding of the proposed project. This section of the proposal shall provide details to the evaluation team about the Vendor's knowledge of the subject and skills necessary to successfully complete the project. Include any required involvement of City staff.

The Vendor shall note if any existing City equipment, software or firmware needs to be replaced or upgraded to provide optimal performance for the ASCT system. The vendor shall note any proposed modifications or additions to detection as two alternatives: minimum additional detection required for ASCT operation and ideal additional detection for ASCT operation. Additional detection equipment would be furnished and installed by the City. The schedule shall assume 5 months for City procurement and installation of any new detection equipment. The exception would be if the proposed system requires a proprietary type of detection. In these cases, the Vendor shall supply the detection for installation by the city. The schedule shall assume 3 months for City installation of vendor supplied

proprietary detection equipment. The Vendor would be required to support implementation of the equipment. Video/radar detection will be used for any new detection not supplied by the Vendor.

4.1.5 System Requirements

The City of Renton developed a list of System Requirements to satisfy City's operational needs. The requirements are categorized as two different types, highly desirable and desirable requirements. Highly desirable requirements are expected to be satisfied by the proposed adaptive system. If any highly desirable requirement is not met by the system, the Vendor shall provide an explanation of why the requirement is not met and if the ASCT system can be updated to meet that requirement. The City prefers the system to satisfy the desired requirements as well. If any desired requirement is not met by the ASCT system, the Vendor shall provide an explanation of why the requirement is not met. The System Requirements document is attached in Appendix B. The Vendor must complete the required fields of the System Requirements document and submit that with the proposal.

Responses to the System Requirements may be submitted on eleven-inch by seventeen-inch (11"x17") paper in landscape or portrait layout.

4.1.6 Project Schedule

Include a project schedule displaying how the project will be completed by the proposed completion date. The schedule shall directly reflect the elements of the proposed Approach/Work Plan. The required start date of the fully deployed ASCT system (prior to verification) shall be prior to February 1, 2017. The schedule shall assume noticed to proceed will be issued by June 20, 2016 (subject to change).

4.1.7 Maintenance, Warranty and Support Plan

The ASCT Vendor shall describe the standard options available for the maintenance of the controller and central software, warranty for any required hardware and levels of support provide in person or remotely for troubleshooting issues with the ASCT. Provide copies of all standard warranties provided. Discuss how a user of the system contacts the Vendor to request help with an issue. Describe the hours of support and options for on-site service. Describe available options for remote support, including telephone, through a VPN connection, or via secure socket layer KVM log in. List names of support staff members and the region they cover within the USA, if applicable.

4.1.8 Buy America Requirements

Provide a certification of materials origin letter, signed by an authorized corporate official indicating that, under penalty of perjury under the laws of the State of Washington, any hardware provided for the construction and implementation of this project meet the requirements of "Buy America" per 23 Code of Federal Regulations (CFR) 635.410 (not to be confused with "Buy American Act") and clarified by Appendix 52.108 of the Washington Department of Transportation (WSDOT) Local Agency Guidelines..

4.1.9 Project Cost

The evaluation process is designed to award this procurement as described to the Vendor whose proposal best meets the requirements of this RFP, provided the cost of the implementation is within the budget. The proposal shall include all costs for system software and licenses, system integration costs

for all intersection hardware and software, training, maintenance, and any other vendor furnished equipment costs.

Vendors are required to collect and pay Washington State sales tax, if applicable. Costs for subcontractors are to be broken out and presented separately. The cost estimate shall be valid for 180 days to provide sufficient time for the selection process and the furnishing and installation of additional detection equipment by the City.

Provide separated costs for the following individual items:

1. Cost for the central adaptive signal control software, 5 client PC licenses, and licenses for the 13 intersections. Cost per intersection for licensing shall be identified. The quantity of intersections may be reduced to fit the project within the grant budget.
2. Cost for two spare units for any device required in the cabinet to interface between the traffic signal controller and the existing detection.
3. Cost for installing and configuring central management software and installation training of client applications on 5 Microsoft Windows 7 Professional PC workstations.
4. Any additional cost for integration and testing support.
5. Cost to upgrade 13 existing 4 MB Eagle M50 controllers to 8MB.
6. Cost for maintenance, warranty and support of the ASCT system for the terms described in section 5.4 of this document. A per year cost per intersection for software maintenance and support shall be provided. This cost shall be fixed for four (4) years beyond the initial year that comes with the purchase. The City may choose to adjust the years of the contract to fit the budget.
7. Cost for training as described in section 5.5 of this document.

4.1.10 References

Provide a list of at least three previous installations of the proposed ASCT in the USA. Provide details of the installation, including the corridor type and the number of intersections operating under the system. Provide contact information for the agencies where the system is deployed, including contact person's name, address, email, and phone number. Locations in the Pacific Northwest are preferred.

4.1.11 Minimum Requirements

The ASCT project requires compliance with the following Minimum Requirements:

- The Vendor must have performed at least three deployments of the proposed ASCT in the United States within the last five years
- The Vendor must have existing customer service support personnel living within the United States
- The proposed ASCT must work for both a grid network and corridor based intersection layout
- The ASCT must operate on or with the existing Eagle M50 (Siemens) controllers.

Provide a narrative describing how your system meets these requirements. Vendors are reminded that Minimum Requirements must be met. The City of Renton reserves the right to reject any and all proposals that do not meet the Minimum Requirements.

In addition to responding to the Minimum Requirements, the Vendor shall provide a description of how the Operational Objectives of each Operational Scenario presented in Section 8 of the Concept of Operations will be met by the proposed adaptive signal system.

4.2 Response Preparation Requirements

Provide four hard copies of the Proposal and one digital copy on a CD/DVD or USB drive in a single sealed envelope. On the front of the envelope, clearly note the following information:

City of Renton Adaptive Signal Control Technology Proposal
ATTN: Flora Lee
RE: SW 43rd St/Carr Road/Petrovitsky Road Adaptive Signal Control Technology RFP

C/O: Jason Seth, City Clerk
City of Renton
1055 S. Grady Way, RM 728
Renton, WA 98057

Proposals are due no later than 4:00 p.m. PST on March 17, 2016 and must be delivered to the City Clerk's office inside Renton City Hall. Call ahead if envelope will be shipped through 3rd party. The City of Renton will not be obligated to accept any late proposals delivered via 3rd party.

5 Selected Vendor Responsibilities

This section defines the selected Vendor responsibilities for this project. The Vendor shall be responsible for all project tasks associated with software installation, configuration, and ensuring proper licensing for the City of Renton. The Vendor shall deliver any required cabinet hardware to the City and support the installation and configuration. The Vendor shall perform the verification testing as specified in the Verification Plan prepared by Vendor and the City of Renton, and shall work together with the City for acceptance testing following training and documentation delivered by Vendor.

5.1 Software Delivery

The proposed ASCT system shall be able to optimize cycle, splits and offset using current vehicle demand data. The software shall not require any code modification except specific customization for implementation and/or operation at intersections in Renton. This also excludes maintenance and security updates. Software architecture shall comply with IT industry best practices and shall support M.S. Windows 7 and 8 client operating systems.

5.2 System and Local Controller Hardware and Software

The Vendor is responsible to provide central server hardware for the central operating system and/or field/central traffic monitoring system. The ASCT system will communicate to field intersections through single mode fiber and existing network hardware TCP/IP or UDP/IP.

The City of Renton expects the system to operate with the existing signal controllers and cabinets. The Vendor shall provide specifications for any additional hardware required in the existing cabinet. If additional hardware is required, it shall be furnished by the Vendor through this contract.

Additional hardware could include a device that provides an interface for the ASCT system to work with the existing loop and future video detection. Installation of any new hardware within the cabinet will be performed by City traffic signal maintenance staff. The Vendor shall assist City staff in installation of any detector hardware; integration of communication hardware with any proposed controller hardware; and configuration, calibration, and integration of the ASCT system.

5.3 System Implementation, Verification, and Validation

The Vendor shall conduct necessary verification tests before (on the bench) and after implementation of the system in the field. The verification testing shall confirm that all the requirements listed in the System Requirements document are satisfied on the bench and in the field. Refer to Verification Plan document attached in the Appendix C for the details of verification testing.

Any failure or lack of performance to meet the stated System Requirements shall be immediately recorded and the Vendor shall prepare a report stating why a System Requirement was not met. The report shall include a proposed solution to resolve the deficiency and shall be submitted to the City within seven days after the failure is discovered. The Vendor shall prepare a report and develop a plan to provide similar performance operation for any System Requirement the Vendor cannot meet. The City does not anticipate any software revisions to provide functionality or operation of Mandatory Requirements. Upon completion of all required verification testing, the Vendor shall prepare a final Verification Report, which will contain all critical information regarding testing conducted, including both failures and successes. Resolution of the cause of failures should also be detailed. A list of all hardware, software and special equipment utilized in the testing shall be provided.

Validation will be conducted by the City of Renton staff or its consultant. The validation conductor will record the results, complete the validation table, and prepare a summary report of the results. The validation tests will be conducted after the system deployment and verification tests are complete. Refer to the Validation Plan document attached in the Appendix D for the details of validation testing.

5.4 System Support, Maintenance and Warranty

The Vendor shall provide on-site and off-site support as appropriate during the system implementation, integration and testing. The Vendor shall configure the ASCT system for optimal traffic operations. Upon implementation and acceptance of the system, the Vendor shall support the software (error corrections and updates) and provide technical assistance, equipment maintenance support, and a warranty for the system. The City requirements and expectations for support are summarized below:

Software Support:

- Up to five (5) years of software assurance and maintenance of all adaptive system software shall be included in the price information requested in Section 4.1.9. Traffic signal controller firmware and central software upgrade files shall be provided to the agency at no additional cost for City staff to install.
- Up to five (5) years of technical support from the Vendor for assistance in using the adaptive shall be included in the price information requested in Section 4.1.9. The Vendor shall provide support within the following response times:
    - Support provided by telephone – 24 hours
    - Support provided via remote login to the system – 24 hours
    - Support requiring Vendor staff on-site – 3 business days or as agreed case-by-case

Warranty:

The Vendor shall warrant Vendor supplied hardware to be free of defects in materials and workmanship for a period of two (2) years. Warranty is defined as correcting defects in materials and workmanship or full replacement. Defect is defined as any circumstance in which the material does not perform according to specification or in the case of proprietary hardware, device ceases to perform as stated by the vendor.

5.5 Documentation/Training

The Vendor shall provide the following system documents in electronic and paper format:

- All presentations and references
- System Operation/Configuration Manual
- User Manual
- Maintenance Manual

The outline and content of these documents shall be subject to approval by the City. The Vendor shall provide training at a City provided location during all aspects of implementation and system operations to include the following:

- ASCT operations
- Troubleshooting
- Preventive maintenance
- Repair of equipment
- System configuration
- System calibration
- System administration

The Vendor shall provide training for a minimum of one day before implementation, minimum of one day after implementation, and minimum of one day after six months of operations.

6 Selection Procedure

Vendor will be selected for work described in this RFP based on evaluation and comparison of all submitted proposals. Each proposal will be initially reviewed by the evaluation committee to determine if the minimum requirements in Section 4.1.11 are met. Failure to meet minimum requirements or to provide a resolution to the failure may result in the proposal being rejected. In the event that all proposals do not meet one or more of the mandatory system requirements, the City of Renton will continue evaluation of the proposals that most closely meet the Minimum Requirements. Accepted proposals will be reviewed by the evaluation committee and scored against the criteria stated in section 7. The evaluation committee may contact references, request presentations, and/or request demonstrations. The resulting information will be used to score respective proposals. Vendor representatives from the top two to three highest scored proposals may be invited for an interview in person in Renton before final selection. The City may request a software demonstration from the Vendor as part of the interview process.

7 Evaluation Criteria

This section describes the criteria to be used to evaluate each proposal. A detailed point system to score the proposals is provided at the end of this section.

7.1 System Requirements

A score of 0 to 60 will be given based on the number of “highly desirable” system requirements met. A score of 0 to 15 will be given based on the number of “desirable” requirements that are met.

7.2 Vendor Experience and Capabilities

A score of 0 to 20 will be given for this section. Each Vendor will be evaluated and scored based on the information provided in the Cover Letter, Project Team Structure, and Staff Qualification and Experience sections.

7.3 Project Approach/Work Plan

A score of 0 to 30 will be given for this section. Each Vendor will be evaluated based on their project understanding and approach. Reviewers will determine if the tasks, activities, schedule and support listed in this section will satisfy the City’s needs.

7.4 Maintenance and Technical Support

A score of 0 to 20 will be given for the maintenance and technical support proposed to be provided by the Vendor. The proposals will be evaluated to verify whether the proposed maintenance and technical support and associated costs are suitable for the City. The evaluation committee will consider the extent of routine maintenance of the system required when scoring this section. The evaluation committee may contact Vendor’s current customers to get information regarding Vendor’s support services and may consider the customers’ responses when scoring this section.

7.5 Deployment Coverage

The grant obtained for this project has a limited budget for covering deployment of the ACST system. Each Vendor will be scored based on the number of intersections that can be deployed based on the base expenses for the system, the per intersection licensing, maintenance cost and the minimally required detection upgrades. A score of 0 to 30 will be provided based on the total coverage that can be obtained. The highest coverage will get the full score and proposals will get a factored score based on the highest proposed coverage. Any proposal that can provide coverage for all 13 intersections within the budget will receive 30 points.

7.6 References

A score of 0 to 25 will be given for this section. Each Vendor will be scored based on the information submitted under the reference section. The evaluation committee will review the submitted information and may contact the references to get information about ASCT systems that were installed.

Table 1: ASCT System Evaluation Criteria

Criteria No	Evaluation Criteria	Total Points	Proposal Points
1a	System Requirements (Highly Desirable)	60	
1b	System Requirements (Desirable)	15	
2	Vendor Experience and Capabilities	20	
3	Project Approach/Work Plan	30	
4	Maintenance and Support	20	
5	Deployment Coverage	30	
6	References	25	
	Total	200	

8 Demonstration

The City of Renton may request a demonstration of the system software at a City provided location. The City may allow a remote demonstration of a system in operation at another agency. If requested, the Vendor shall install the system, provide required hardware, and demonstrate the fully operational system in a test bench environment.

9 Contact Information

Further inquiries and questions concerning this RFP must be submitted in writing via email by March 9, 2016 no later than 4:00 p.m. PST to:

Flora Lee, Project Manager
Email: FLee@rentonwa.gov

The City will respond to the questions and clarification requests to all Vendors by March 11, 2016.

Appendix A: Concept of Operations

City of Renton

SW 43rd Street/ Carr Road/ Petrovitsky Road Adaptive Signal Control Technology

Concept of Operations

HSIP-000S(306)

Prepared by DKS Associates

December 2015

DKS

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1 SCOPE

1.1 Document Purpose and Scope

The scope of this document covers the consideration of adaptive signal control technology (ASCT) for use within the City of Renton on the SW 43rd St/SE Carr Rd/SE Petrovitsky Rd, East Valley Highway, and SR 515/108th Ave SE corridors. The Renton Adaptive project will potentially implement ASCT on these major arterials for 13 intersections:

- SW 43rd St & Oakesdale Ave SW
- SW 43rd St & Lind Ave S
- SW 43rd St & E Valley Rd
- SW 41st St (SR 167 Southbound Ramps) & E Valley Rd
- SW 43rd St & SR 167 NB Ramps
- SW 43rd St & Talbot Rd S
- SE Carr Rd & 98th Ave S (Smithers Ave)
- SE Carr Rd & 106th Pl SE
- SE Petrovitsky Rd & SR 515 (Benson Dr S) (108th Ave SE)
- SE Petrovitsky Rd & 116th Ave SE
- SE Petrovitsky Rd & 128th Ave SE
- Benson Rd S & SR 515 (Benson Dr S)
- SE 180th St & SR 515 (108th Ave SE)

This document describes and provides a rationale for the expected operations of the proposed adaptive system. It documents the outcome of stakeholder discussions and consensus building that has been undertaken to ensure the system that is implemented is operationally feasible and has stakeholder support. It is part of the System Engineering Documents that is developed and used to select and deploy an ASCT system for the City of Renton. This document illustrates user-oriented operational description, operational needs, and an envisioned adaptive system overview, including a clearly defined vision, goals and objectives, adaptive operational environment, support environment, and various operational scenarios.

The intended audience of this document includes: traffic engineers, administrators, decision-makers, elected officials, other non-technical readers and other stakeholders who will share the operation of the system and/or be directly affected by its operation.

This document is part of the overall stakeholder-driven process to evaluate various adaptive signal technologies through a systems engineering process in order to select an ASCT system to deploy in the City of Renton. In addition to the City of Renton, other primary stakeholders include WSDOT and the FHWA. Secondary stakeholders include the King County, City of Kent, and City of Tukwila.

1.2 Project Purpose and Scope

The purpose of this project is to identify an upgrade to Renton's existing traffic signal system that would provide reasonable and predictable travel times and an improvement in traffic operations and progression over their existing time-of-day signal coordination. The existing coordination currently has backups under normal conditions, and also has difficulties with fluctuations in traffic and cut through movements when freeway conditions are oversaturated. The City of Renton would like to improve operations during predictable and unpredictable heavy traffic events. Such events include increased traffic detouring onto Talbot Rd S and SR 515/108th Ave NE due to an incident on I-405 or SR 167; heavy congestion on arterials during the holiday season; other unpredictable incidents.

Renton's existing field components of their signal system provide the detection and communication infrastructure. The existing corridor was upgraded as part of the Trans-Valley ITS project in 2005. This project interconnected the signal systems with fiber optics, added stop bar and advanced loop detection, and upgraded the controllers for the entire corridor. An adaptive traffic signal system responds to changes in traffic conditions by automatically adjusting signal timings, such as cycle lengths, splits, and offsets in response to traffic conditions measured in near real time.

1.3 Procurement

Procurement of the ASCT system will be through a request for proposals process that evaluates the proposals based on which system will best meet the needs of the City of Renton, approach to the implementation, history of operations, and cost.

Renton's existing signal system uses TACTICS (Siemens) for central operations and Eagle M50 (Siemens) controllers running the SEPAC software. This corridor is maintained and operated by the City of Renton. This corridor was previously operated by King County and recently turned over to the City of Renton to operate the signals. The Trans Valley project (2005) installed extensive loop detectors. Renton would prefer to build upon this existing investment and select a system that is compatible with the central signal system, the existing traffic signal controllers, and the existing loop detection.

2 Referenced Documents

The following documents have been used in the preparation of this Concept of Operations and stakeholder discussions. Some of these documents provide policy guidance for traffic signal operation in this area; some are standards with which the system must comply; while others report the conclusions of discussions, workshops and other research used to define the needs of the project and subsequently identify project requirements.

- *Intelligent Transportation Systems (ITS) Regional Architecture,* Puget Sound Regional Council, http://www.psrc.org/assets/3515/Final_Report_20AUG-06_updated_22DEC-08.pdf
- *Systems Engineering Guidebook for ITS*, California Department of Transportation, Division of Research & Innovation, Version 3.0, http://www.fhwa.dot.gov/cadiv/segb/>

- *Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems,* Federal Highway Administration, http://ops.fhwa.dot.gov/publications/fhwahop11027/

3 User-Oriented Operational Description

This section presents the current conditions (existing situation); the City of Renton's goals and objectives for signal system operations; and describes other non-adaptive strategies considered.

3.1 The Existing Situation

This subsection describes each corridor and their signal operational characteristics. It also describes the signal operational limitation identified for each corridor.

3.1.1 Network Characteristics

This section breaks down the project area into a description of how each portion of the study area operates (i.e., as an arterial, grid network or isolated intersection). There is also a highway interchange, SR 167, within the project area that must be addressed.

3.1.1.1 Arterial

The ASCT system is proposed on two major arterial corridors in the City of Renton; SW 43rd St/SE Carr Rd/Petrovitsky Rd runs east/west and is roughly perpendicular to SR 167.

SR 515/108th Ave SE/Benson Drive S runs north/south through the City and roughly parallels SR 167. A map of the project intersections is shown on Figure 1.

<u>SW 43rd St/ S Carr Rd / SE Petrovitsky Rd</u>

The section of roadway along SW 43rd St/S 43rd St/S Carr Rd/SE Carr Rd/SE Petrovitsky Rd from Oakesdale Ave SW to 128th Ave SE is approximately 3 miles long and includes 10 signalized intersections. For the purposes of this document, this will be referred to as the Carr Rd corridor. The tightest grouping of signals along this roadway segment is the ¾ mile segment between Lind Ave SW and 98th Ave S (Smithers) which includes 5 closely spaced signalized intersections. These intersections are 750' to 1000' apart from one another and include the Northbound on/off ramps to SR 167. Intersections along this segment have cycle lengths that range from 110 seconds to 135 seconds.

<u>SR 515 / 108th Ave SE / Benson Dr S</u>

The section of roadway along SR 515 / 108th Ave SE / Benson Dr S from Benson Rd S to SE 180th St is approximately ½ mile long and includes 3 signalized intersections. For the purposes of this document, this will be referred to as the SR 515 corridor. The Benson Rd S intersection lies 800 ft. north of the SE Petrovitsky Rd intersection. The SE 180th St intersection lies 1400 ft. south of the SE Petrovitsky Rd Intersection.

Legend

- Project Intersection (City Maintained) with Existing Loop Detection.
- Other Signalized Intersection
- CCTV (PTZ Camera), Existing
- 1-36 SMFO Interconnect, Existing

N

PROJECT MAP

S CARR ROAD

Figure 1 - Project Map

3.1.1.2 Cycle Lengths

Depending on the location along the corridor, intersections run six to eight timing plans during the week and five timing plans on the weekends. Intersections are split into two groups depending on their timing plan. Group A intersections are west of SE Carr Rd & 106th Pl SE. Group B intersections include SE Carr Rd & 106th Pl SE and all intersections east of this point. The only exception is SE 180th St & SR 515 (108th Ave SE). This intersection runs free (non-coordinated) for all day except for the PM period. During this period it is coordinated in the north and south directions.

Both groups have similar timing plans during the weekends with 110 seconds in the late AM and 120 seconds in the mid-day and PM.

During the weekdays, the groups are very similar. The main difference is Group A runs 120 seconds in the mid-day whereas Group B runs 110 seconds in the mid-day. The cycle lengths for each group are shown in Table A and Table B.

Table A - Group A Intersections Weekday Cycle Lengths

Time	Cycle Length (seconds)
12:00 AM – 5:15 AM	Free
5:15 AM – 9:00 AM	130
9:00 AM – 10:45 AM	110
10:45 AM – 2:00 PM	120
2:00 PM – 7:00 PM	135
7:00 PM – 9:30 PM	110
9:30 PM – 12:00 AM	Free

Table B - Group B Intersections Weekday Cycle Lengths

Time	Cycle Length (seconds)
12:00 AM – 5:15 AM	Free
5:15 AM – 9:00 AM	130
9:00 AM – 2:00 PM	110
2:00 PM – – 7:00 PM	135
7:00 PM – 12:00 AM	Free

3.1.1.3 Detection

All project intersections currently utilize inductive loops for vehicle detection. Diagrams showing loop detection at each intersection are included in Appendix B. Any required maintenance, repair, or connections to existing loops prior to the installation of the ASCT system will be performed by the City.

3.1.1.4 Highway Interchange

SR 167 is a major north/south highway which connects the cities of Renton, Kent, and Auburn to the I-5 and I-405 freeways. There are two SR 167 half-interchanges within the project extents. The first is a southbound on and off ramp for southbound SR 167. It is located one block north of the Carr Rd corridor. Vehicle traffic coming to/from the east and south must use the Carr Rd corridor in order to access the southbound interchange. The northbound SR 167 half-interchange exits/enters directly from the Carr Rd corridor.

3.1.1.5 Jurisdictions

All proposed adaptive intersections are operated and maintained by the City of Renton. King County owns and operates the SE Petrovitsky/134th Ave SE intersection, the first intersection east of the project area. WSDOT owns the traffic signal at the northbound SR 167 half-interchange; however, this intersection is still operated and maintained by the City of Renton.

3.1.1.6 School Zone

There is a 20 mph school zone with beacon at the New Horizon School. This zone begins at S Carr Rd and 98th Ave S and heads east approximately 750 ft. This beacon is active twice per day Monday through Friday from 7:30 am – 8:30 am and 2:00 pm to 3:00 pm.

3.1.1.7 Holiday Schedule

Two different strategies are currently implemented to help alleviate holiday traffic. Because of the variability that is associated with holidays, 13 of the intersections run "Free" for 24 hours on the following days:

- Thanksgiving Day, Thursday
- Christmas, December 25
- Day after Christmas, December 26
- New Years, January 1

The second strategy is used for the three days following Thanksgiving (Friday/Saturday/Sunday). During this period, shopping traffic increases dramatically as vehicles access Ikea, Costco, and other nearby destinations. This coordination plan is used on all 43rd St SW/Carr Rd intersections from Oakesdale Ave to 116th Ave NE. The cycle lengths of that plan are shown in Table C.

Table C - Post-Thanksgiving Holiday Coordination Plan

Time	Cycle Length (seconds)
12:00 AM – 5:15 AM	Free
8:00 AM – 8:00 PM	130
8:00 PM – 10:00 PM	110
10:00 PM – 12:00 AM	Free

3.1.2 Traffic Characteristics

The following subsections describe how the traffic signals in the study area operate during various typical travel periods.

3.1.2.1 Overview

In the study area, there are several corridors which experience high volumes of traffic throughout the day (volumes shown are rounded, and based on mid-week data collected in March 2015. Starting hour shown for peak hour volumes):

- E Valley Hwy Corridor
  - 21,000 ADT - 23,000 ADT
  - AM peak hour volume of 800 vehicles NB (7 am)
  - PM peak hour not defined at a consistent hour ~ 800 vehicles.
- SR 167 NB off-ramp to S Carr Rd (affected by study area)
  - 11,500 ADT - 12,000 ADT
  - AM peak hour volume of 1,150 vehicles (7 am)
  - PM peak hour not defined at a consistent hour ~ 675 vehicles.
- SW 43rd St/S Carr Rd Corridor (east of SR 167 NB ramp)
  - 39,000 ADT – 41,000 ADT
  - AM peak hour volume of 1,300 vehicles WB (6 am)
  - PM peak hour volume of 1,950 vehicles EB (5 pm)
- SE Petrovitsky Road (east of SR 515)
  - 27,000 ADT - 30,000 ADT
  - AM peak hour volume of 1,100 vehicles WB (6 am)
  - PM peak hour volume of 1,300 vehicles EB (5 pm)
- SR 515 Corridor (south of Petrovitsky)
  - 27,000 ADT - 30,000 ADT
  - AM peak hour volume of 1,250 vehicles NB (6 am)
  - PM peak hour volume of 1,250 vehicles SB (5pm)

Each corridor has unique characteristics that must be addressed separately. The traffic demand for each corridor is outlined in Appendix A. The summarized data also includes a graphical summary of the volume data for each corridor.

3.1.2.2 Emergency Pre-Emption

Valley Medical Center is located on the north side of the Carr Rd corridor near Talbot Rd S. On the east side of the intersection of SR 515 and SE 180th St is Renton Fire Department Station 13. This station responds to a significant number of emergency calls requiring the use of pre-emption.

The City of Renton has advanced pre-emption at westbound SW 43rd St & 98th Ave S (Smithers Ave) towards westbound SW 43rd St & Talbot Rd S. Advanced pre-emption allows an approach intersection to receive a call and distribute it to other downstream intersections.

The following charts demonstrate a typical weekday pre-emption event log at four of the intersections within the study area.

Note: Pre-emption events were logged between the hours of 6:00 AM to 7:00 PM. The dates of each pre-emption survey are shown in the individual charts.

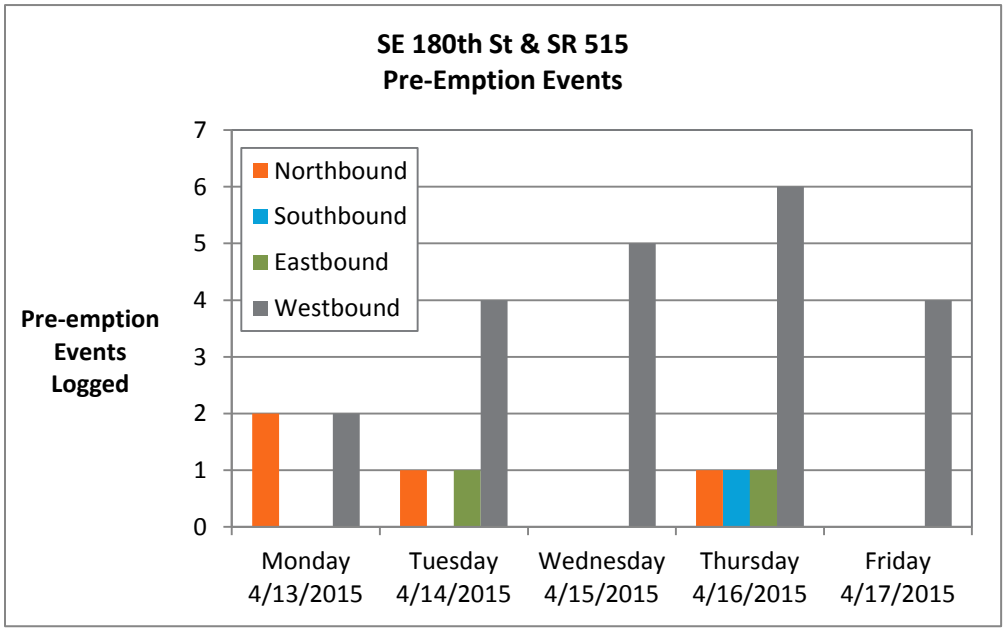


Figure 2 - SE 180th St & SR 515 Pre-Emption Events

There is a fire station located on the east side of the intersection of SE 180th St & SR 515. The highest rate of calls occurs in the westbound direction from vehicles responding to calls and exiting the fire station.

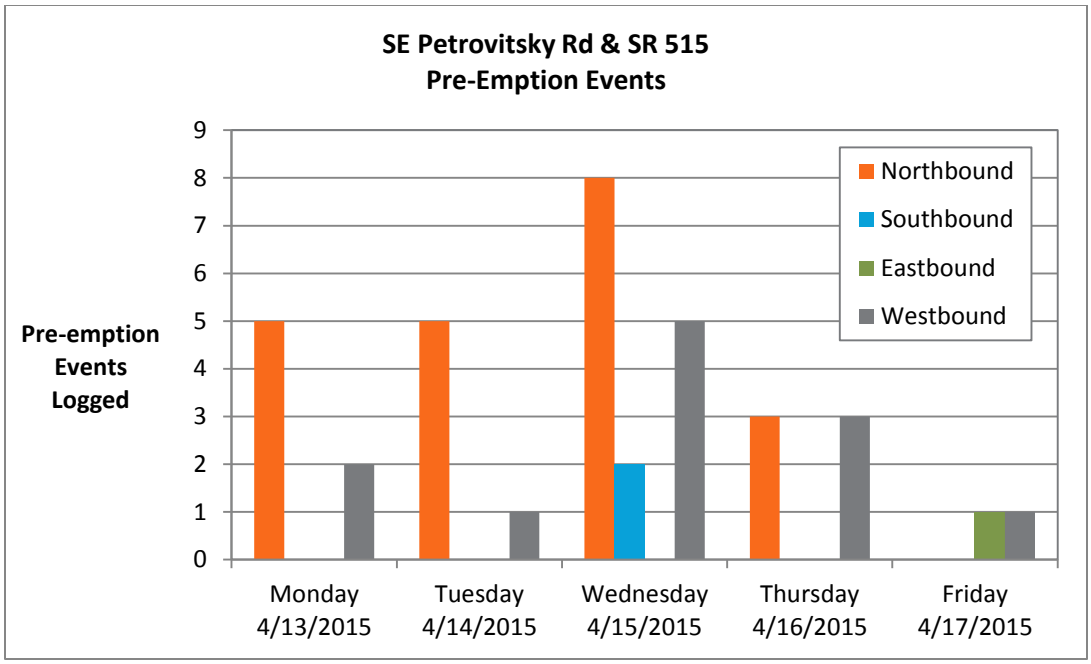


Figure 3 - SE Petrovitsky & SR 515 Pre-Emption Events

Emergency vehicles exiting the fire station at SE 180th St turn north onto SR 515. This creates a high pre-emption demand in the northbound direction at SE Petrovitsky Rd & SR 515.

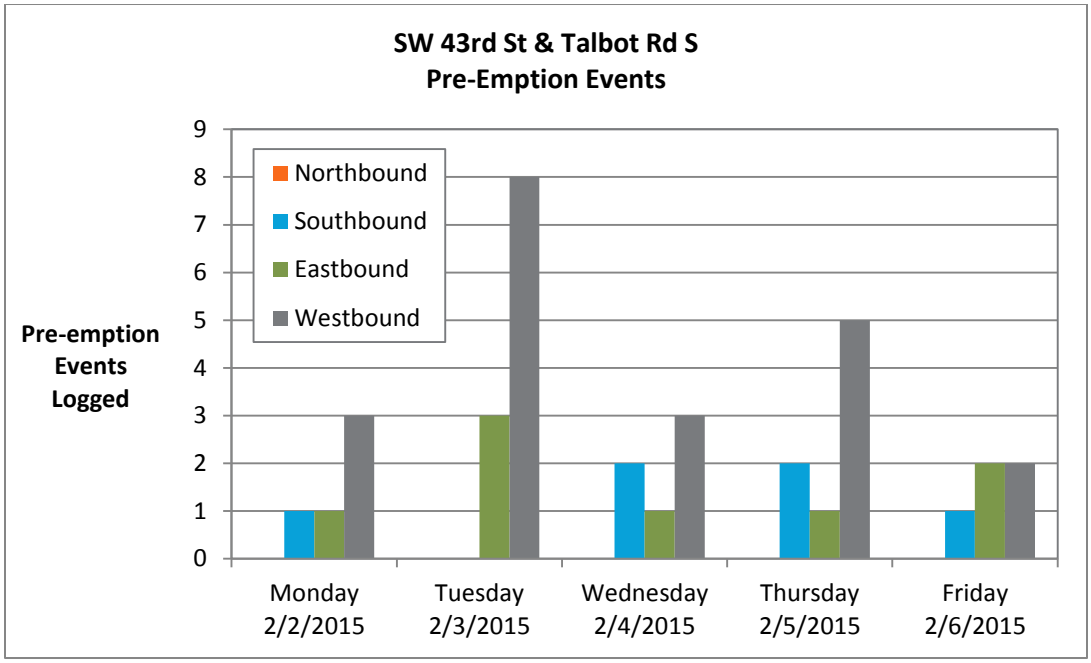


Figure 4 - SW 43rd & Talbot Rd S Pre-Emption Events

SW 43rd & Talbot Rd S is an intersection which connects Valley Medical Center to the Carr Rd corridor. There is a high demand from vehicles heading towards west from the fire station. However, additional

demand in the eastbound and southbound direction occurs from emergency vehicles accessing the Valley Medical Center.

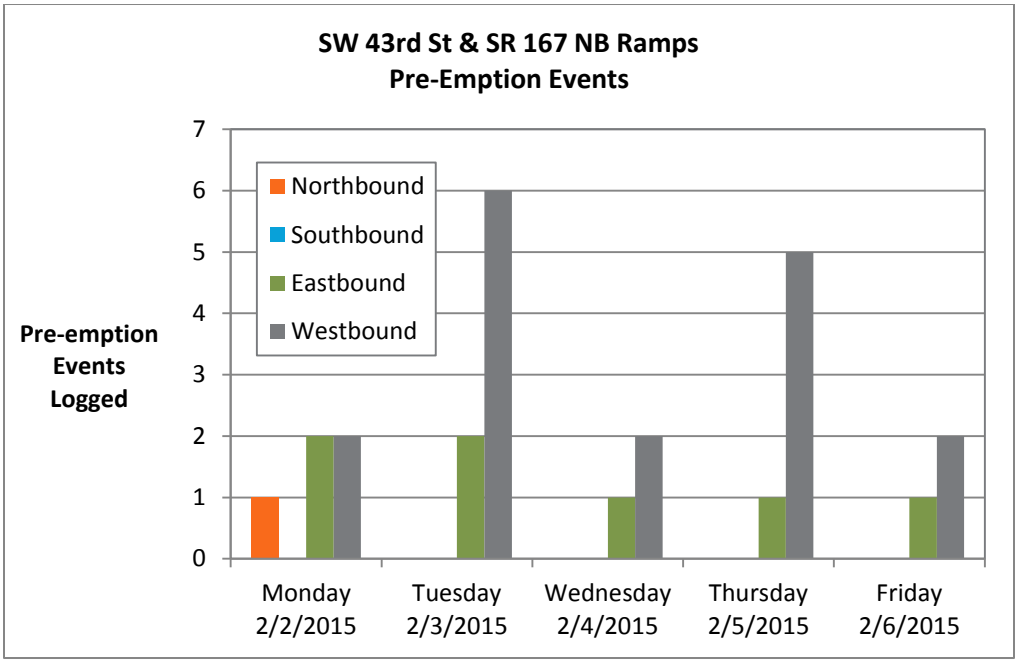


Figure 5 - SW 43rd St & SR 167 NB Ramps Pre-Emption Events

The half-interchange at SW 43rd St & SR 167 NB Ramps has a high rate of pre-emption calls in the westbound direction due to outbound emergency vehicles. There is some additional demand in the eastbound direction as emergency vehicles head east towards Valley Medical Center.

3.1.3 Accident History

Accident data was collected and reviewed for the study intersections. Accident data was collected from January 2010 to November 2014. The following charts break down the data by year over year, each intersection, and type of accidents.

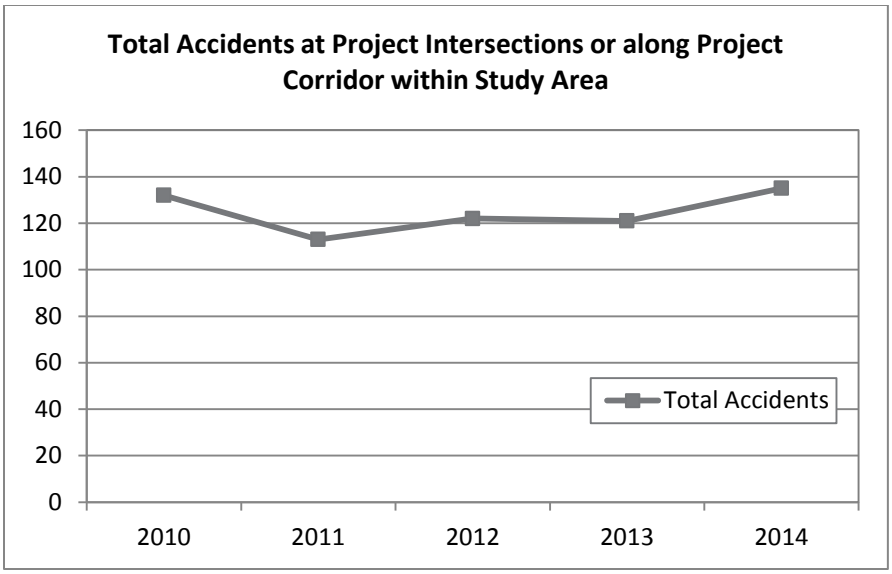


Figure 6 - Total Accidents on Carr Rd by Year

Figure 6 displays the total number of accidents along Carr Rd within the project study area. The rate of accidents on Carr Rd has remained consistently high over the past 5 years. On average an accident occurs once every 3 days within the project study area.

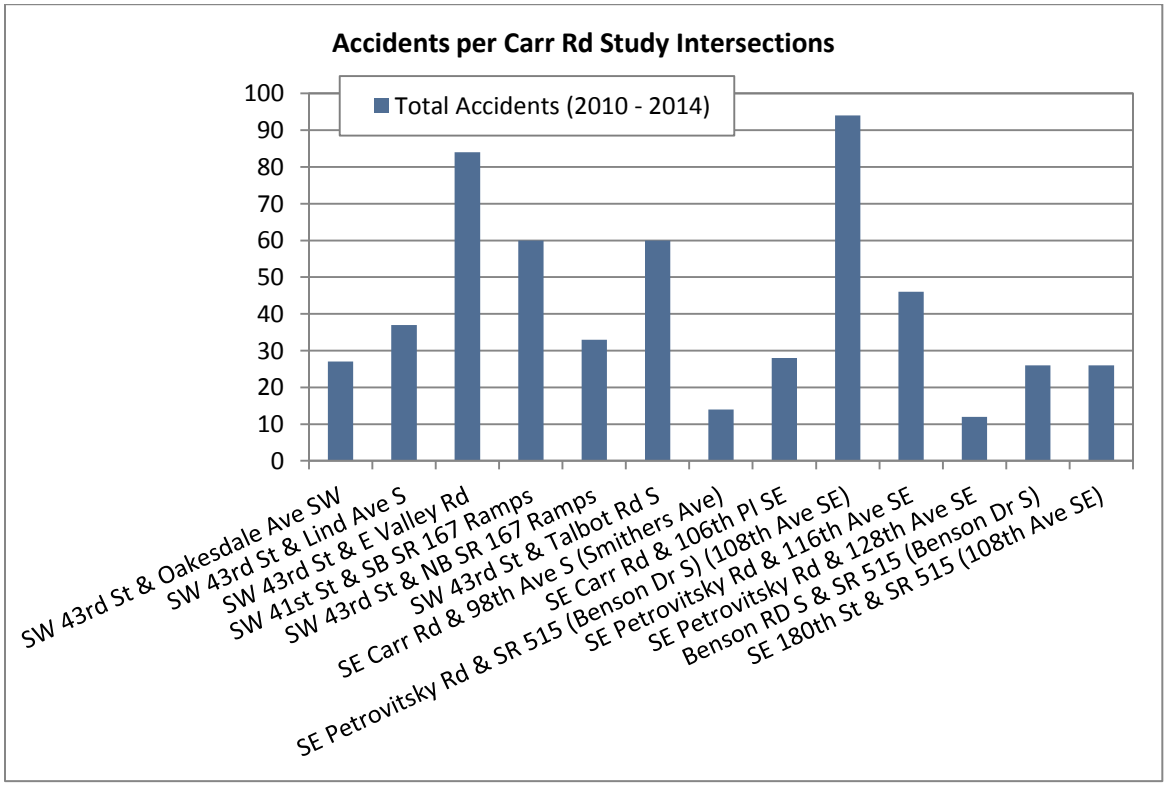


Figure 7 - Accidents at Carr Rd Project Study Intersections Add accident data for SE Petrovitsky Rd & 108th Ave SE

The highest number of collisions occurred at SE Petrovitsky Rd & SR 515. A high accident rate also occurred at SW 43rd St & E Valley Rd.

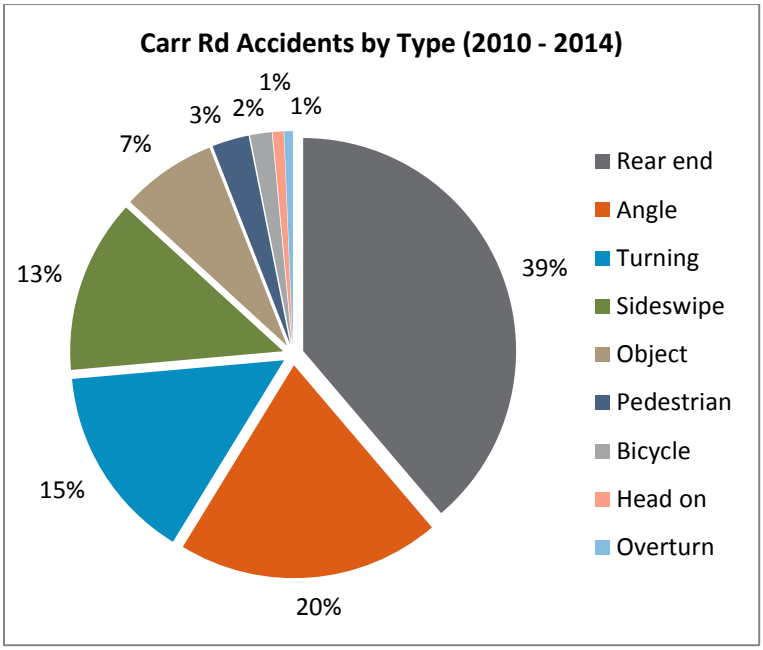


Figure 8 - Carr Rd Accidents by Type

Figure 8 details the type of collision for each accident. More than one half of the collisions are a rear end or angle type, which are typically at or related to intersections. The high rate of rear end collisions especially highlights the issues caused by congestion and queuing. This is especially concerning for the ramp related incidents which can be high-speed collisions from vehicles exiting SR 167.

3.1.4 Land Use Characteristics

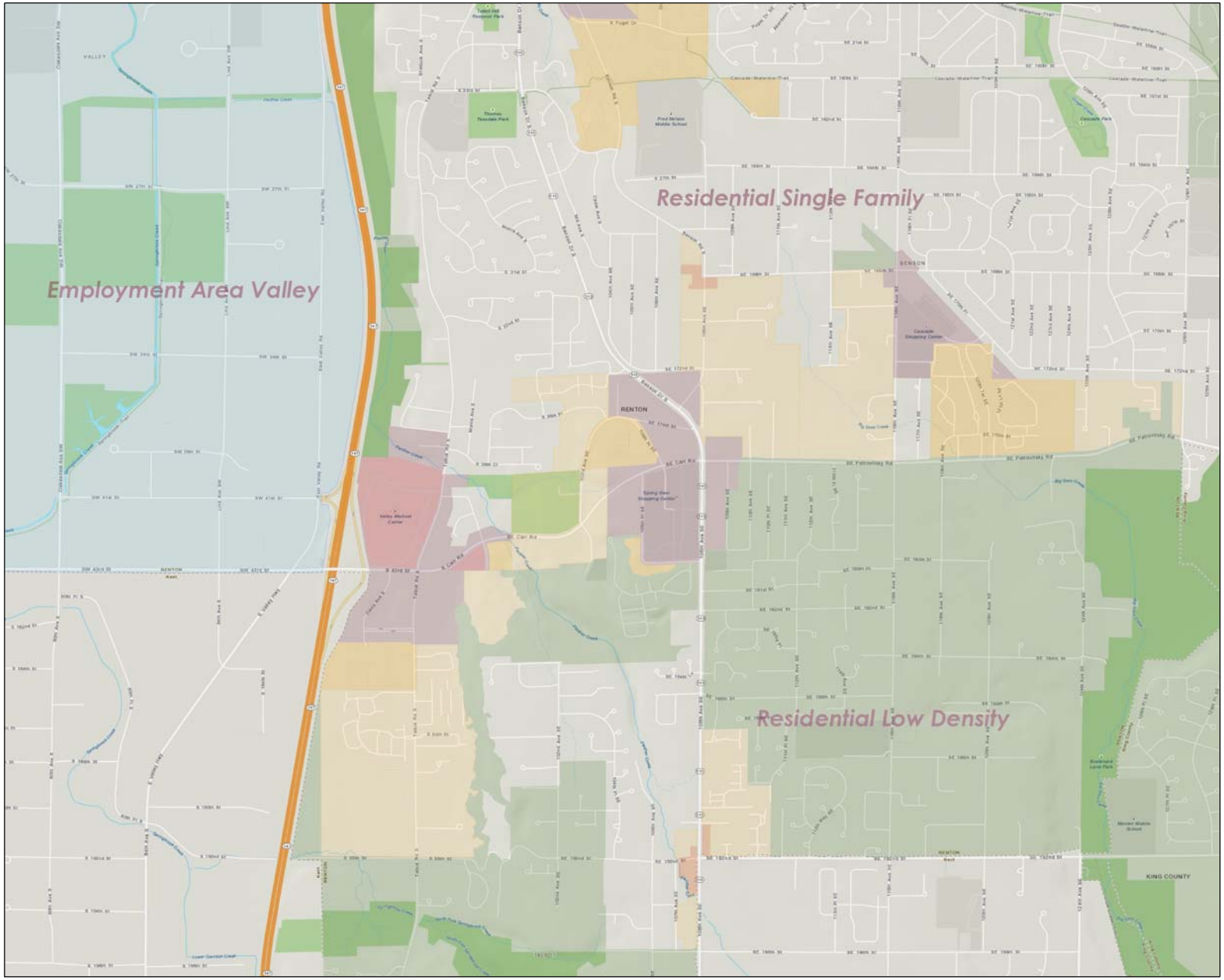
The following subsections describe the land uses within the project area and infrastructure that supports the traffic signal network.

3.1.4.1 Existing Land Uses

On the Carr Rd corridor starting from Oakesdale Ave SW east to SR 167 is the Valley Employment Area, which includes a large IKEA commercial building. SR 167 to SR 515 is a mix of residential, hospital, school, commercial, and employment areas. The Valley Medical Center is located at the NW corner of SW 43rd St and Talbot Rd S. The New Horizon School is located at the SW Corner of Mill Ave S and SE Carr Rd. In addition to having a very distinct set of land uses, this area also experiences the highest level of congestion.

East of SR 515 to 128th Ave SE is predominately residential low density on the south side of SE Petrovitsky Rd and residential single to medium family on the north side of SE Petrovitsky Rd. There are no proposed future land use changes. The following page displays a map of the current land use in the study area.

Carr Rd Corridor Land Use



Legend

Comprehensive Landuse

- Residential Low Density
- Residential Single Family
- Residential Medium Density
- Residential Multi-Family
- Center Village
- Urban Center Downtown
- Urban Center - North
- Employment Area - Industrial
- Emplyment Area - Valley
- Commercial Neighborhood
- Commercial/Office/Residential
- Commercial Corridor

Notes

2062 0 1031 2062 Feet

WGS_1984_Web_Mercator_Auxiliary_Sphere

DKS Associates

02/27/2015

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

City of Renton
Finance & IT Division

3.1.5 Public Transit

Transit in the project study area consists of three routes. The characteristics of each route are as follows:

King County Metro Route 153

- Route:
  - Lind Ave SW (North of SW 43rd St)
  - Carr Rd (Lind Ave SW to E Valley Rd)
  - E Valley Rd (South of SW 43rd St)
- Schedule
  - Weekday: Every 30 minutes 6 AM – 8 AM, Every 30 minutes 3 PM – 6 PM
  - No other service

King County Metro DART Route 906

- Route
  - Carr Rd
- Schedule
  - Weekday: Every 1 hour 6 AM – 7 PM
  - Saturday: Every 1 hour 8 AM – 7 PM

King County Metro Route 169

- Route
  - Talbot Rd S (North of Carr Rd)
  - Carr Rd (Talbot Rd S to 108th Ave)
  - 108th Ave SE (South of Carr Rd)
  - Stops by Valley Medical Center
- Schedule
  - Weekday: Every 30 minutes 5 AM – 12 AM
  - Saturday: Every 30 minutes 6 AM – 12 AM
  - Sunday: Every 30 minutes 7 AM – 12 AM

A small amount of bus delay occurs due to congestion in the study area. However, it is not the main focus of the existing condition. Currently transit signal priority is not utilized within the study area. It is implemented in other areas throughout the City of Renton.

3.1.6 Pedestrian

There is minimal pedestrian volume at the project intersections. The highest pedestrian activity occurs at intersections adjacent to Valley Medical Center and SE Petrovitsky Rd & SR 515. These intersections have low level demand characteristics for pedestrian crossings.

3.1.7 Existing Traffic Signal Infrastructure

The City of Renton controls all the traffic signals within the study area (and across most of Renton) through their Traffic Management Center located at Renton City Hall. Below are some of the key features of Renton's signal system:

- Most traffic signal controllers in the project area are M50 Siemens in TS2 cabinets. Controllers communicate with the City of Renton TMC via Ethernet over fiber. TS1 cabinets that will need to be replaced by city staff due to compatibility reasons and age of the cabinets exist at the following intersections:
    - SW 43rd St & SR 167 NB Ramps
    - SW 41st St (SR 167 Southbound Ramps) & E Valley Rd
    - Benson Rd S & SR 515
- M50 controllers will need to be upgraded from 4MB to 8 MB memory cards for all 13 intersections.
- Existing CCTV Cameras exist at four locations in the study area. The cameras communicate to the traffic management center using fiber. Existing cameras are located at the following locations:
    - SW 43rd St & E Valley Rd
    - SW 43rd St & Talbot Rd S
    - SE Petrovitsky & SR 515
    - SE Petrovitsky Rd & 116th Ave SE

3.2 Limitations of the Existing system

The following are the limitations identified for the existing signal system:

- The existing system cannot be reasonably programmed to address each of the typical changes of traffic volumes on each corridor, especially since conditions can vary greatly from one end of a corridor to the next. The result is that four to six time-of-day plans are prepared for the entire corridor in an attempt to find programs that are the best fit for the average condition.
- The existing system cannot detect unexpected changes in traffic demand, such as increased volume due to congestion or incidents on SR 167. As a result, the congestion is greater than would be the case if the signal timing could automatically adjust to the unexpected conditions. This would also reduce the need for manual intervention by operators when an incident is brought to their attention.
- The existing system cannot adapt to heavy volumes associated with the Southcenter regional mall during busy shopping seasons or fluctuations in traffic caused by the weather.
- The existing system cannot adjust to excessive queuing without creating new coordinated timing plans and potentially adversely impacting other intersections on the corridor that aren't experiencing the same queuing issue.

3.3 Proposed Improvements to the System

3.3.1 Proposed Improvements

The following improvements are proposed to address the limitations noted in the previous section:

- Provide the ability to react quickly and automatically to changes in traffic conditions due to incidents and general fluctuations in traffic.
- More efficiently recover from an emergency vehicle pre-emption event. This is especially of importance due to the close proximity to the Valley Medical Center.
- Improve the management of queues within the network.
- Improve the management of traffic on each corridor to allow for changes in signal groupings to address varying conditions in different parts of the corridor.
- Keep signal timing current rather than letting its efficiency deteriorate between periodic signal re-timing efforts.

3.3.2 Project ITS Architecture

The ITS Architecture for this project involves different agencies and stakeholders, transportation and communication sub-systems. The ITS Architecture is developed from the Puget Sound Regional Council ITS Architecture Turbo Architecture file. The primary agencies that are involved in this project are WSDOT, City of Renton traffic management, and King County Roads. The interaction between the transportation elements and communication methods are illustrated in Figure 9.

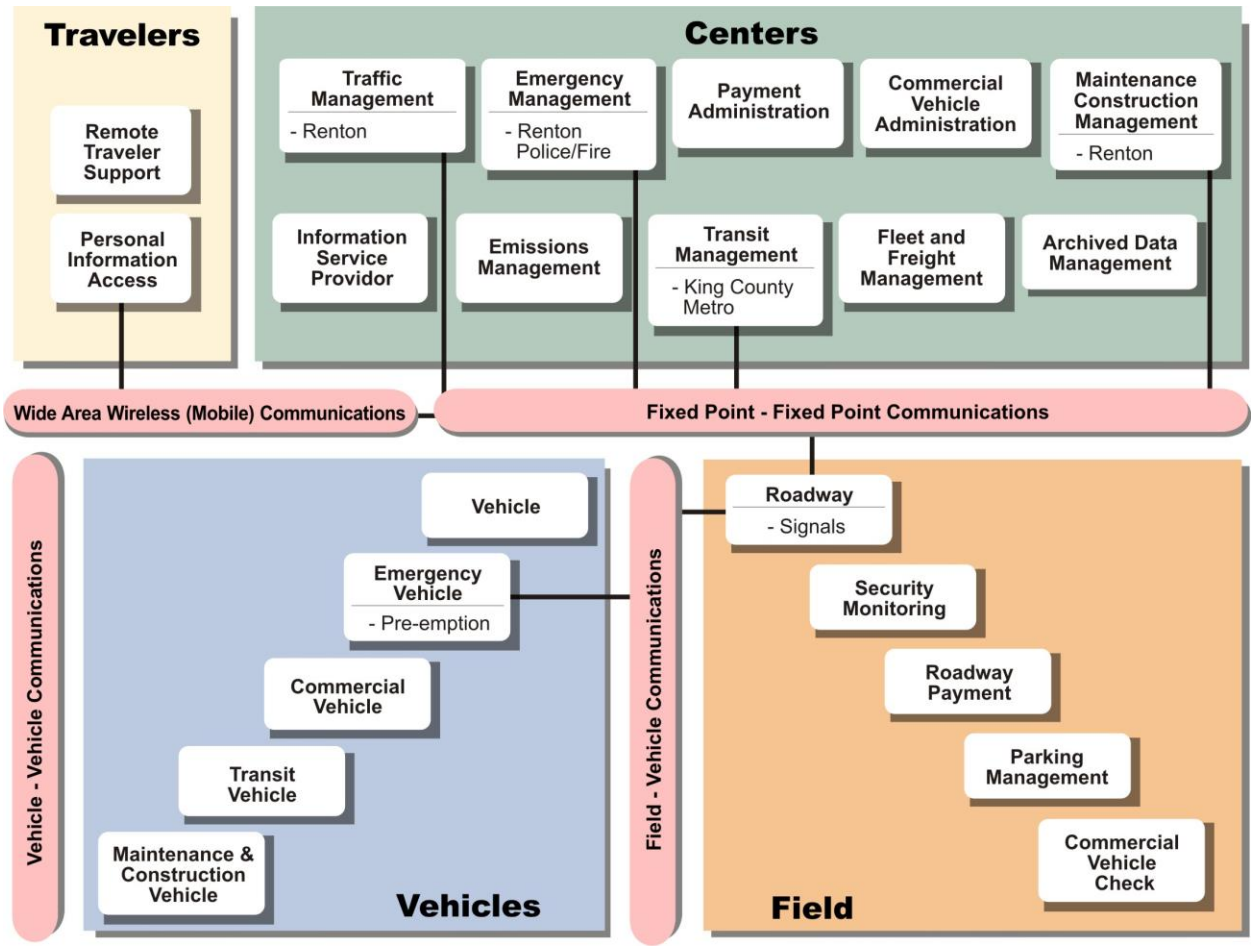


Figure 9 - Renton Subsystem Interaction

No changes will be required to the existing Regional ITS Architecture to accommodate this project.

Security for ITS systems is represented in two forms through the National ITS Architectures, "Securing ITS" and "ITS Security Areas." Securing ITS is defined as the security portion of all subsystems included in the project. ITS Security Areas are additional functions ITS can support to maintain a secure surface transportation system. Deployment of the adaptive system does create the need for addressing an ITS Security Area. Security of the adaptive central control is critical to the safe performance of the signal system.

3.4 Vision, Goals and, Objectives for the Proposed System

3.4.1 Vision

The vision of the adaptive system is to provide an advanced traffic control system that supports the efficient movement of motor vehicles through the corridor; minimizes queuing and delays especially near freeway ramps; and quickly responds to changing traffic conditions resulting from freeway incidents and emergency vehicle pre-emptions.

3.4.2 Goals

The goals of the adaptive system are:

- Support vehicle and pedestrian mobility through the project corridor by reducing delay
- Support reasonable and reliable travel times for vehicles through the project corridors
- Maximize efficient use of capacity of the existing and future roadway
- Improve safety
- Reduce Delay

3.4.3 User Objectives

The following is a summary of the objectives that support each of the defined goals:

<u>Support vehicle and pedestrian mobility through the project corridor</u>

- Enable the capabilities of the traffic signal controllers to manage varying traffic conditions
- Use and maintain lower cycle lengths
- Optimize splits, cycles, and offsets
- Provide measurable improvements in personal mobility

<u>Support reasonable and reliable travel times for transit and general purpose vehicles through the project corridors</u>

- Continually adjust traffic signal operations to match changing conditions in real-time in each unique part of the corridor
- Increase the number of vehicles arriving on green
- Manage queue spillback
- Quickly recover from pre-emptions on the corridor

<u>Maximize efficient use of capacity of the existing and future roadway</u>

- Improve progression of traffic through real-time optimization of arterial corridors
- Make more efficient use of green time at each intersection

<u>Improve safety</u>

- Reduce traffic congestion/conditions which are prone to vehicle collisions

3.5 Strategies to be applied by the Improved System

The future signal system must have the ability to accommodate multiple operational strategies to support the varying conditions throughout the project area. The main arterial corridor in the project area, SW 43rd St/Carr Rd/Petrovitsky, will need the ability to act like a “pipeline” during the AM and PM peak periods that flushes traffic down the corridor as efficiently as possible.

The system will need to have the ability to closely monitor SR 167 queues. The signalized intersections which control traffic exiting SR 167 will need to reduce any queues from extending onto mainline SR 167. Otherwise there is a safety risk of a high speed rear end collision.

Additionally, the system needs to be able to handle overcapacity conditions. These conditions occur when the traffic demand exceeds the capacity of the roadways, regardless of signalization. In these situations the system needs the ability to manage and minimize queue lengths as well as prevent intersection blocking scenarios.

3.6 Alternative Non-Adaptive Strategies Considered

3.6.1 Traffic Responsive Pattern Selection (TRPS)

TRPS has been considered, but is not considered a viable solution to the project needs. TRPS has limited efficiency due to its configuration characteristics. TRPS requires the operator to develop multiple timing plans (10-15) in attempt to address all possible operational scenarios. The operator then needs to determine the detection thresholds that will activate each of these plans. A minimum time of operation for a plan must also be determined. The result is a system that is either switching plans to often or is switching plans too late following a measured change in traffic conditions. A transition to a new plan can take the SEPAC software up to three cycles. During this transition period, there is limited coordination along the corridor. The Carr Rd corridor is often at a near critical state, and loss of coordination would cause unwanted disruption.

The City of Seattle has implemented TRPS using the same controllers and central system used by Renton. They have seen some benefit, but it was the result of significant time dedicated to fine tuning each plan and the triggers that activate the plans. The fixed plans would then need to be updated again in the future as conditions evolve. An adaptive system would be able to work beyond the fix plans and would not require a significant redevelopment in the future.

An adaptive system will require traffic engineering support, but the level of support is anticipated to be significantly less that the time required to maintain TRPS. The operator will need to observe traffic and provide input to the system, but it won't require the intense modeling efforts to develop the initial timings and to test potential changes. In addition, an adaptive system can be selected that will be compatible with the existing signal system.

3.7 Complex Coordination Features

The following features are currently used in coordination patterns and will need to remain available in fallback operation should the ASCT fail:

- Multiple (repeat) phases or phase re-service
- Variable phase sequence
- Detector switching
- Early release of hold
- Late phase introduction

- Dynamic max
- Floating force-offs
- Offset correction transition features
- User selected fixing of phase sequences at user selected locations.
- Emergency pre-emption and advanced pre-emption
- Double cycle or half cycle
- Omit phase under some circumstances
- Hold the position of uncoordinated phases
- Coordination of phases by time of day
- Coordination of turn movement phases

4 OPERATIONAL NEEDS

This chapter describes the operational needs that should be satisfied by the proposed ASCT system. Each of following sections describes operational needs that must be met by the future system to achieve the goals of this project. Each of these needs will be satisfied by compliance with one or more system requirements. The needs are defined below for adaptive strategies, network characteristics, coordination across boundaries, security, pedestrians, non-adaptive situations, system responsiveness, complex coordination and controller features, monitoring and control, performance reporting, failure notification, pre-emption and priority, failure and fallback, constraints, training and support, external interfaces, and maintenance.

4.1 Adaptive Strategies

The system operator needs the ability to implement different strategies individually or in combination to suit different prevailing traffic conditions. These strategies include:

- Maximize the throughput on coordinated routes
- Provide smooth flow along coordinated routes
- Distribute phase times in an equitable fashion
- Manage the lengths of queues
- Manage the locations of queues within the network
- Manage a pre-emption event efficiently
- Optimize operation with a minimum of phase failures at an isolated intersection when not operating under coordination
- Adjust the grouping of signals to provide the operational scenario that best fits unique areas of the project
- Change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions
- Detect repeated phase failures and control signal timing to prevent phase failures from building up queues
- Minimize the chance that a queue forms at a specified location

- Modify the sequence of phases to support the various operational strategies
- Fix the sequence of phases at any specified location (e.g., the operator may need to fix the phase order at locations where a lagging left turn provides unsafe operations)
- Designate the coordinated route based on traffic conditions and the selected operational strategy
- Set signal timing parameters (such as minimum green, maximum green and extension time) to comply with agency policies

4.2 Network Characteristics

The ASCT system will consist of a deployment of adaptive operations at 13 signals in the study area. Of these 13 signals, 10 will be along the Carr Rd corridor. Possible future expansion could increase the number of signals to 14. These signals vary in distances up to 10 miles from the Renton TMC.

The system operator needs to be able to adaptively control up to 4 independent groups of signals. The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.

4.3 Coordination across Boundaries

There is no plan to control traffic signals across agency boundaries at this time. Future extensions of this project could include traffic signals operated by the City of Tukwila and/or King County Roads Division.

4.4 Security

Traffic engineering and maintenance staff will be assigned different levels of authority, and access to equipment and software for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.

In order to accomplish this, the system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.

4.5 Queuing Interactions

The traffic engineer will need to detect queues within the system's boundaries and modify the adaptive operation to accommodate the queuing. This could include identifying areas within the system that can support excessive queuing better than others. For example, allowing or not allowing queuing based on proximity to adjacent intersections. There are also locations within the project area where additional effort should be made to minimize queues, such as roadways departing shopping centers where stacking of cars can be difficult.

One specific area where queuing needs to be monitored closely is at the SR 167 half-interchange intersections. Queues from the traffic signals shall not extend onto the highway due to the signal timing.

4.6 Pedestrians

Different pedestrian management strategies will be required depending on the area of the project. In areas of high pedestrian volume, intersections need to accommodate frequent pedestrian operation into routine adaptive operation. For low volume areas, the system needs the ability to handle sporadic demand and recover accordingly. The system operator needs to accommodate intermittent pedestrian operation while maintaining adaptive operation.

4.7 Non-Adaptive Situations

It is anticipated that adaptive control shall operate at all times. The system operator needs to pre-determine traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present. The system operator needs the ability to schedule pre-determined operation by time of day. The user should also have the ability to override adaptive operations and have manual control. The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.

4.8 System Responsiveness

The responsiveness of the system shall be user programmable. The system operator needs the ability to limit the frequency of cycle changes, if necessary, and also provide limits for the minimum and maximum cycle length. The system should monitor traffic and adjust in real-time to changes in traffic or queuing. In this case real-time is defined as the current traffic conditions at the time of system response.

4.9 Complex coordination and controller features

The following advanced controller features shall be maintained by running adaptive operations:

- Service a phase more than once per cycle
- Operate at least four overlap phases
- Operate four rings, 16 phases, and up to eight phases per ring
- Permit phases or overlaps (multiple) by time-of-day schedule or external input.
- Protected/permissive phasing and alternate left turn phase sequences
- Prevent one or more phases being skipped under certain traffic conditions or signal states
- Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
- Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day
    - Ability to hold a flashing yellow arrow until a conflicting pedestrian movement clears
    - Ability to hold a flashing yellow arrow until adequate gaps in traffic are detected
    - Ability to switch to protected only operations based on volume inputs, external inputs or by time of day

- Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using certain extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors
- Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination (e.g., double-cycle, mid-block pedestrian crossing signals)
- Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination
- Use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk
- Permit different phase sequences under different traffic conditions
- The ability to operate different phase sequences based on different traffic conditions or by time-of-day
- The ability to adjust operations based on a time-of-day schedule
- The ability to omit or skip a phase under some traffic conditions or based on external input to allow a shorter cycle length to operate, or to provide additional time to other phases
- The ability to maintain coordination with external movements by preventing phases from being skipped, or by omitting phases, based on time-of-day, external input or when certain phase sequences are in operation.
- The ability to designate any phases in use as coordinated phases (one per ring)
- Allow the coordinated phase to terminate early under prescribed traffic conditions
- Allow coordination with double cycle or half cycle to better serve pedestrians
- Allow pedestrian phase recycle operation
- Synchronization of controller clock daily
- Permit phases or overlaps by time-of-day schedule or external input

The system shall also accommodate the following custom features used by this agency:

- Bike Green
- Bike Passage
- Bike Detection
- Walk offsets
- Extended Pedestrian clearances
- Detector Switching
- Four+ phase banks

4.10 Monitoring and Control

The system users need to be able to monitor and control all required features of adaptive operation from the City of Renton. The operator needs access to the database management, monitoring and reporting features, functions of the signal controllers, and any related signal management system from

the access points defined for those system components. Field and outside requests will be directed to the Engineer at the TMC. Additional control should occur from workstations on agency LAN or WAN at Renton City Hall, local controller cabinets, and remote locations through VPN into the network.

4.11 Performance Reporting

The following performance reporting is required for the future system:

- The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation
- The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system and export selected data in Excel or CSV format
- The system operator needs to store and report data that can be used to measure traffic performance under adaptive control
- The system needs the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions
- The system needs to store and report data used to calculate signal timing and have the data available for subsequent analysis

4.12 Failure Notification

Failure events associated with the adaptive system shall be reported to maintenance and operations staff through texts or e-mail, depending on user-defined parameters. All failures should be logged.

4.13 Preemption

The system needs to accommodate emergency vehicle pre-emption. The system shall assess queues following a preempt event and determine the quickest means of recovery and return to management of platooning traffic. The system should be able to actively adjust between long-way or short-way offset correction. The system needs the ability to accommodate advanced pre-emption as currently being tested at SW 43rd St & Talbot Rd S.

4.14 Failure and Fallback

In the event of equipment, communications, and software failure, the system needs to fall back to pre-defined time-of-day plans without causing disruption to traffic flow. Use of alternate detectors or historic data to maintain adaptive operations during a failure is also a desirable feature.

4.15 Constraints

The City would prefer that the chosen ASCT system be able to use the existing loop detection since equipment is already in place at each intersection. However, the City would be open to supplementing the loop detection equipment with video detection equipment for the following case: the ASCT system meets all other operational needs and requirements and requires new detection equipment within a pre-determined budget. Any new detection equipment will be City furnished and installed.

4.16 Training and Support

The City of Renton needs all staff involved in operation and maintenance to receive appropriate training. The City of Renton needs the system to fulfill all requirements for the life of the system. Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment

Therefore, the City needs the system vendor to continue support of the system to repair faults that are not defects in materials and workmanship. All requirements of the system shall be maintained for this defined life. The vendor shall include a warranty for the system. The City of Renton may require a source code escrow agreement with the vendor. In the event of a knockdown, Signal Technicians must be able to program and replace controllers in the field without communications.

Upon completion of the project, city staff must be knowledgeable and comfortable enough to install a new intersection without the assistance of the vendor or manufacturer. Vendor assistance and inventoried equipment must be available on-site within two hours.

4.17 External Interfaces

There are no existing external interfaces that will impact adaptive operations.

4.18 Maintenance

The City needs all applicable equipment to be readily accessible. The City needs to have spare parts for critical equipment.

4.19 Transit and Signal Priority

The system operator needs to accommodate bus transit priority while maintaining adaptive operations at an intersection or on a corridor. Transit signal priority is not currently used in the study area. However, transit signal priority shall remain an option for future implementation.

5 ENVISIONED ADAPTIVE SYSTEM OVERVIEW

This section describes the envisioned adaptive system for the City of Renton. The envisioned adaptive system is defined by the size and grouping of intersections, operational objectives, fallback operation, crossing routes and adjacent systems, operator access, and complex coordination and controller operation.

5.1 Size and Grouping

The City of Renton plans to adaptively control approximately 13 intersections. The system shall define the grouping of intersections based on the measured conditions on the corridors. A group of intersections may be comprised of simply one intersection, or up to the total number of intersections that are sufficiently close to warrant coordination under the prevailing traffic conditions. During some traffic conditions, there may be separate groups of intersections operating with different characteristics

(e.g., different cycle lengths, intersections running in and out of coordination, offsets in different directions). The city would prefer options to group signals by time of day, manually, or conditionally.

The city may be interested in expansion of the adaptive system in the future based on the performance results of the Carr Rd System.

5.2 Operational Objectives

The objective of the coordination will be to provide for smooth flow of traffic along the Carr Rd corridor. The corridor progression needs will change throughout the day and vary based on incident conditions.

The objective of the coordination will be to manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system.

The system will have the ability to help recognize when different strategies for traffic management are needed. The system operator shall also have the ability to modify how the system makes these decisions.

The operator will have the ability to define groups of intersections to set operational objectives; however, the desire is for the system to do this automatically.

During moderate to light traffic conditions, protected left turns may be omitted. Thresholds for managing protected lefts shall be defined by the system operator.

Within these operational objectives, the ASCT system will change its operation to accommodate the rise and fall of volumes through the peaks and the changing patterns of flow throughout the day and week. However, there is also a stochastic element to traffic in the short term, with the number of arrivals for a phase varying from cycle-to-cycle, and pedestrians not being present on all phases in all cycles.

It is therefore desirable for the system to have some local tactical control. While vehicle-actuated coordination typically allows phases to run longer or shorter from cycle-to-cycle to match the actual number of vehicles using the phase, the system will also allow the operator to decide where the unused time will be used. If a phase is to be skipped, the operator can specify that the spare time will be added to the existing phase, the following phase or the next coordinated phase.

At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, phase sequence and phase times in real-time to match the changing traffic conditions.

5.3 Fallback Operation

The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group and the use of up to eight coordinated plans that are activated by time-of-day.

The system will also have a fallback state that allows individual intersections to operate in a vehicle-actuated, isolated mode in the event of failures of the adaptive processor software or hardware, detectors or communication.

Before falling back to pre-defined timings, the system will attempt to maintain adaptive progression by allowing one or more intersections to be slaved from a critical intersection. Failure of a loop will be resolved by using historic detector data to manage operations and/or use of an alternate loop. There will be a user-defined limit on the number of failed detectors that can be managed by one intersection. After this threshold is met, the controller will revert to a user-defined recall plan.

5.4 Crossing Routes and Adjacent Systems

A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads. This would include the three project corridors: Carr Rd, SR 515, and East Valley Hwy.

5.5 Operator Access

Traffic engineering and maintenance staff from Renton will be assigned different levels of authority and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.

5.6 Complex coordination and controller operation

The agency will use the following complex coordination and controller features:

- Allow the operator to specify which phase receives unused time from a preceding phase
- The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement
- Allow any phase to be designated as the coordinated phase
- Allow the coordinated phase to terminate early under prescribed traffic conditions
- The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available
- The agency may operate external devices using discrete signal outputs from the ASCT including occupancy on a detector, cycle length, and time-of-day (user selects desired features)
- Following a pedestrian phase, coordination needs to recover within one cycle.

6 ADAPTIVE OPERATIONAL ENVIRONMENT

The system will primarily be operated and monitored by City of Renton staff from the Renton TMC.

The central server equipment will be housed at the City of Renton TMC. The central server will be a standard platform (maintained by the City IT Department) and able to be replaced independently from the software.

The system will use some combination of existing TS2 cabinets, M52 controllers, and loop detection. The system must be compatible with M52 controllers and loop detection. The system operator shall not require any modifications to the existing controller software and central system.

Initial setup of the adaptive system will be performed by the system vendor. The City shall receive training on how to perform this setup so they have the option to add intersections in the future or make changes to timings for intersections in the initial deployment. The vendor will be used on an on-call contract basis to provide support as needed with the setup of new intersections or fine-tuning of the system.

The City of Renton will be responsible for addressing all complaints received with timings at project area traffic signals.

7 ADAPTIVE SUPPORT ENVIRONMENT

7.1 Institutions and Stakeholders

Existing primary stakeholders of the traffic signal system include:

- City of Renton
- WSDOT
- FHWA

7.2 Facilities

The existing City of Renton TMC is located at Renton City Hall, 1055 S Grady Way, Renton, WA 98057. Any required central applications for adaptive shall be able to run on a virtual server built in an existing server at City Hall. The City Traffic operation manager and other support staff will be responsible for all maintenance of the signal system hardware in City Hall.

7.3 System Architecture Constraints

The adaptive processor/server will be protected within the City's firewalls. The City's Traffic Engineer will provide resources, equipment and system management so that operators will have appropriate access to the system locally, from within the City's LAN, and from remote locations as described within this document.

The communications media available for use by the system will be the City of Renton's fiber/Ethernet network. The adaptive system will operate within the local ITS Architecture (Transportation network) of the City.

7.4 Utilities

There is no required coordination with other utility groups within Renton.

7.5 Equipment

Any additional test equipment required to support the adaptive system needs to be identified by the ASCT vendor. The vendor will provide this testing hardware or software as part of their installation contract.

7.6 Computing hardware

Rack space is available for additional computer hardware in the TMC. Hardware necessary for installation of the adaptive system shall be compatible with existing hardware in the TMC. Any hardware provided will be maintained by Renton traffic signal operation and maintenance staff.

7.7 Software

The system operator needs to use equipment and software acceptable under current agency IT policies and procedures with the City of Renton.

7.8 Personnel

The signal system will be operated by City traffic engineering, traffic operation manager, and maintenance staff. This staff will be available during normal business hours, but can respond to alarms outside of business hours, depending on the severity. The system chosen shall supportable by existing staff.

Operations and maintenance staff from Renton will need training on the selected system by the system integrator. Adequate training shall be provided so City of Renton staff can operate the system and configure new intersections. All training will occur on-site at the City of Renton. The agency needs all staff involved in operation and maintenance to receive appropriate training.

Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of and following system deployment.

The City of Renton traffic operation manager will be the administrator for the signal system software. He will be responsible for managing the number of users and associated licenses. He will also be responsible for processing renewals of software assurance contracts, if needed.

7.9 Operating Procedures

City of Renton traffic signal operation staff will be responsible for backing up databases on a regular basis.

7.10 Maintenance

Maintenance will be performed as described in section 7.8.

8 OPERATIONAL SCENARIOS

8.1 Overview

The following operational scenarios describe how the system is expected to operate under various conditions. The proposed ASCT system is expected to be able to manage the following operational scenarios and issues envisioned for both the current and future project locations. Scenarios are described for the following operational conditions:

- Typical heavy congested conditions
- Typical heavy uncongested conditions
- Typical light traffic conditions
- Fault conditions

8.2 Typical Heavy Congested Conditions

8.2.1 Traffic Conditions

During the AM and PM peak, traffic is often congestion close to the SR 167 Ramps. In the AM peak, the northbound off ramps can have queues that back into the SR 167 shoulder up to ½ mile.

In the PM peak period, southbound traffic on East Valley Highway becomes a bottleneck. This is due to high traffic volumes from the SR 167 Southbound ramps looking to make a left turn onto S 43rd St. while facing backup conditions of queues between the two half-interchanges.

In the AM and PM peak period traffic westbound east of the SR 167 northbound ramps experiences heavy delay and long queues.

8.2.2 Operational Objectives

The City of Renton's objective during the period of heavy congestion is to try and clear queues in one cycle and create progression between intersections. Distribution of green time will be important at minor intersections that are not driving the overall cycle length for these corridors.

8.2.3 Coordination and Signal Timing Strategies

Coordination during these events will require the system to manage a careful balance of creating the green-band opportunities that promote moving traffic, while managing queues in turn pockets and on side streets. Side street queuing can be tolerated in locations where it doesn't impact adjacent signals, emergency access, or private property. Queuing in left turn or right turn pockets that could potentially spill into an adjacent through lane must be avoided.

Queuing on SR 167 off-ramps shall be monitored based on any detector inputs available and the frequency of force-offs. The system will need to balance the time allocated to these movements to assure traffic is not backing up onto the SR 167 mainline.

8.2.4 Summary of Operation

The signal system will monitor volumes and arrival of platoons on the corridor and actively adjust cycle lengths, splits and offsets to manage the demand and progression of traffic. As traffic reaches saturation in the peak travel direction(s), the system will need to start prioritizing these movements in an attempt to keep traffic moving in the primary direction. Queuing will be monitored on critical movements defined by the user to assure the emphasis on progressing the mainline traffic is not having an unacceptable adverse effect on other movements.

8.3 Typical Heavy Uncongested Conditions

8.3.1 Traffic Conditions

Heavy, uncongested traffic is experienced throughout most of the project area between 9 AM and 2 PM during the weekdays. It also occurs on the weekends between 11 AM and 5 PM. However, weekend traffic can be unpredictable and become congested quickly. Traffic remains heavy in the east and west directions along Carr Rd. Additionally the northbound and southbound approaches at SR 515 and Petrovitsky Rd experience heavy volumes throughout this period.

8.3.2 Operational Objectives

Maintaining progression during these periods is important to reduce stops and maximize throughput. More emphasis can be provided to reduce queuing as well, when the mainline is not oversaturated. A secondary objective will be to get cycle lengths as low as possible to reduce the wait time for pedestrians.

8.3.3 Coordination and Signal Timing Strategies

The coordination strategy will be very similar to the congested strategy. Moving platoons of traffic is critical, but managing queues will be of equal importance. An attempt shall be made to assure queues at all intersections clear in one cycle. Cycle lengths will be kept low to help reduce queuing at intersections.

8.3.4 Summary of Operation

The signal system will monitor volumes and arrival of platoons on the corridor and actively adjust cycle lengths, splits and offsets to manage the demand and progression of traffic. Force-offs will be monitored on all approaches to assure each are receiving adequate time to clear queues. Queue detection may be needed in locations that have recurring problems. Equal emphasis will be given to clearing queued traffic and maintaining progression.

8.4 Typical Light Traffic Conditions

8.4.1 Traffic Conditions

Light conditions are experience in the off-peak on weekdays after 8 PM and on the weekends outside of the hours of 11 AM to 5 PM. There are limited queuing issues and some phases are skipped because of no demand.

8.4.2 Operational Objectives

The objective during this period is to continue promoting progression along major arterials, but keeping wait times on side streets and protected turn movements low. Protected left turns could be turned off during this period where protected-permissive signals are provided. The operator shall also have the ability to set a volume threshold that would trigger groups of signals to run free.

8.4.3 Coordination and Signal Timing Strategies

The coordination approach for this condition is to provide progression along the arterial, maximizing bandwidth while providing two-way coordination. The timing strategies applied to do this are:

- At each intersection, provide sufficient time to serve all turning and side street traffic without phase failures
- At each intersection, select phase times (or offsets) that provide a smooth flow along the arterial in both directions
- At intersections with protected-permissive left turns, omit protected turning phases to minimize the impact of occasional turning vehicles on other traffic
- At each intersection, select phase times that will accommodate occasional use of pedestrian phases
- Keep cycle lengths low to reduce wait times

8.4.4 Summary of Operation

The adaptive system will continue to promote progression, while working to reduce wait times for pedestrians and side streets and assure that all phases clear in one cycle. Once volumes reduce below a user-defined level, the adaptive system will shut off and the traffic signals will run free.

8.5 SR 167 Delays and Incidents

8.5.1 Traffic Conditions

In the AM peak period, SR 167 delays cause drivers to divert onto the parallel SR 515. During events of significant SR 167 delays, a higher percentage of drivers will take the off ramps onto Carr Rd. This puts a high volume of vehicles onto Carr Rd and SR 515 that would not otherwise route in that direction.

8.5.2 Operational Objectives

The top priority during incidents is to keep traffic moving on the local arterials so that diverting SR 167 traffic does not lead to incidents on local streets. As with heavy conditions, the peak travel direction will be favored for progression. Queuing on side streets will be tolerated to promote pushing traffic through the corridor. The signals at the freeway can act like meters to the arterials to limit the amount of traffic dumped each cycle. This will be balanced with minimizing queue spill onto SR 167.

8.5.3 Coordination and Signal Timing Strategies

Coordination during these events will primarily focus on providing a green band to the diverting traffic. Management of side street queuing will be the secondary emphasis of the system. As with heavy congestion, certain movements may be designated as critical movements where queuing is not

tolerated, such as routes that provide emergency access. Queuing in left turn or right turn pockets that could potentially spill into an adjacent through lane must be avoided.

8.5.4 Summary of Operation

The traffic signal system will detect the sudden spike in traffic volumes and start to adjust splits and cycle lengths to manage the increased traffic. Throughput in the diversion direction will be the primary focus for the adaptive system, as will monitoring queuing on designated critical movements.

8.6 Emergency Vehicle Preemption

8.6.1 Emergency Vehicle Preemption

When an intersection responds to emergency vehicle pre-emption, other signals within the coordinated group continue to operate adaptively. The preempted signal returns to adaptive control once the pre-emption is released. The City of Renton is currently studying doing advanced pre-emption at several Carr Rd intersections. In these situations, call shall be placed at an approach intersection, and downstream intersections will also receive this call.

8.7 Fault Conditions

8.7.1 Communications Fault Condition

If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation. The fallback mode will be specified by the user based on location and time-of-day.

8.7.2 Detection Fault Condition

The system will recognize a detector failure and take appropriate action to accommodate the missing data. For a local detector failure, the local controller will place a soft recall or maximum recall (to be user-specified) on the appropriate phase, and issue an alarm. For a detector that influences the adaptive operation (e.g., a system detector), the system will use data from an alternate (user-specified) detector, such as in an adjacent lane or at an appropriate upstream or downstream location. The detector can also use historic data. If the number of detector failures within a specified group exceeds a user-specified threshold, the system will cease adaptive operation and go to a fallback operation specified by the user (such as time-of-day operation or free operation). The fallback operation will be specified by the user based on location and time-of-day.

8.7.3 Processor Fault Condition

If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation. During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller. The fallback mode will be specified by the user based on location and time-of-day.

8.7.4 Alerts and Logs

All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention. The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.

9 APPENDIX A – CORRIDOR SUMMARIES

9.1 E Valley Hwy Corridor

E Valley Hwy is the main connection between three main north south highways: W Valley Hwy, SR 167, and SR 515. The following figures display the traffic counts along the corridor. Traffic counts were collected on E Valley Hwy, just north of SW 43rd St.

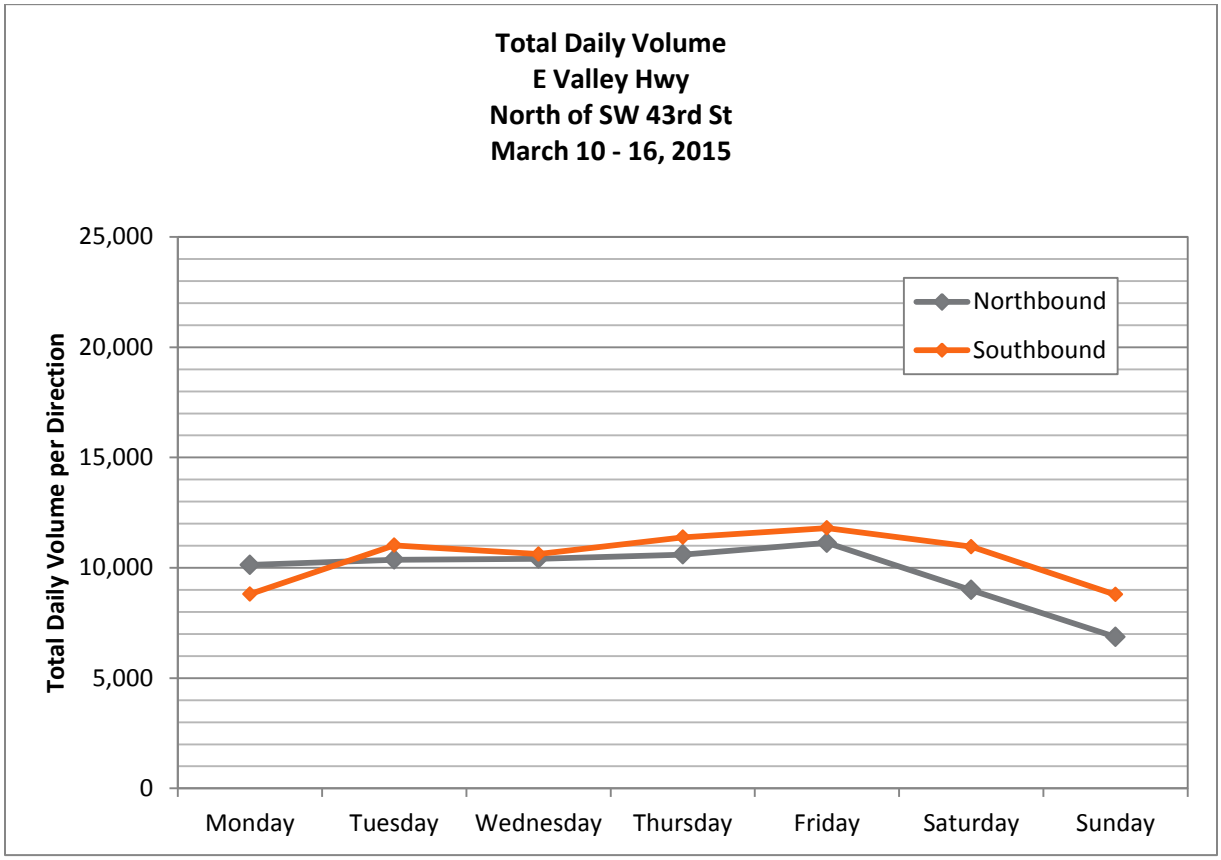


Figure 10 - E Valley Hwy Total Daily Volume

Traffic remains consistent throughout the weekdays with a slight dip during the weekends. Generally, the southbound traffic remains slightly higher than the northbound traffic due to motorists exiting SR 167 southbound.

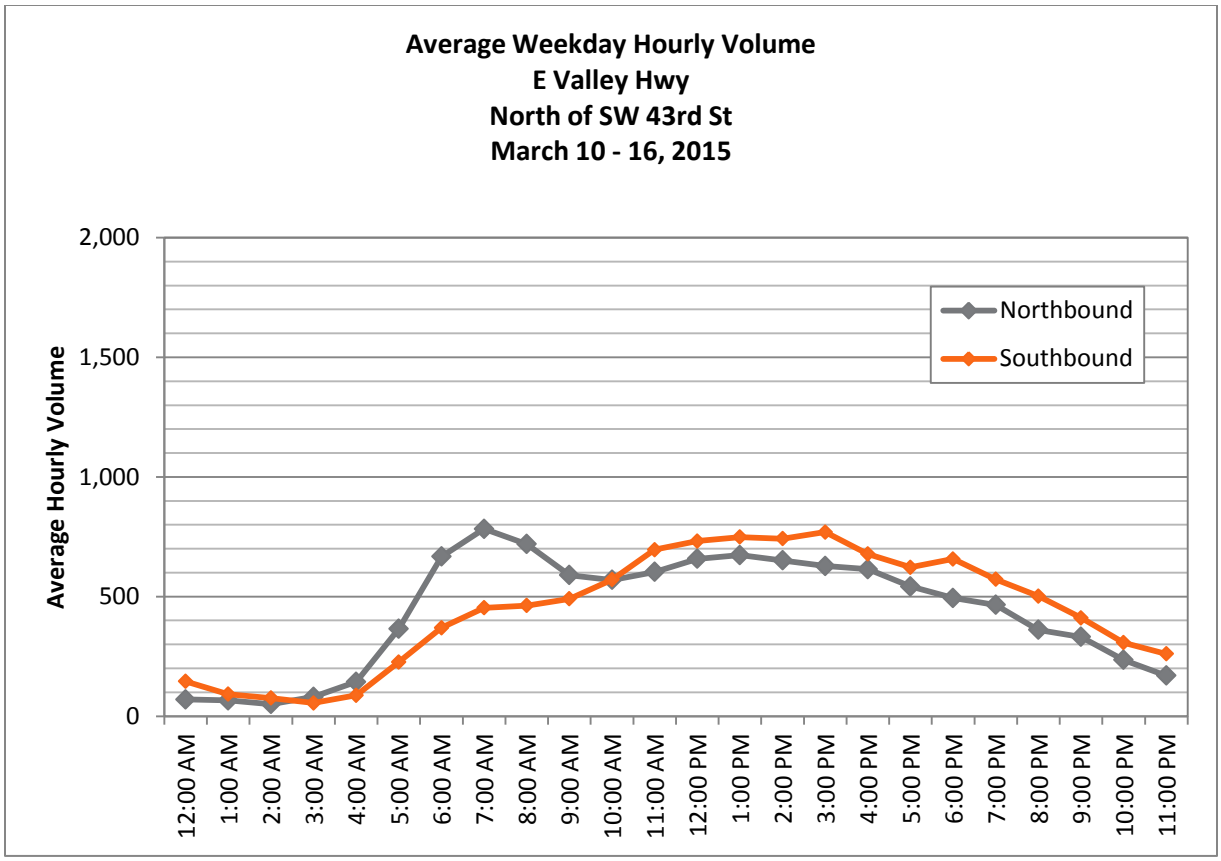


Figure 11 - E Valley Hwy Average Weekday Hourly Volume

Compared to the other measured sites, the total hourly volume remains lower throughout the day. An AM peak period occurs between 6:00 – 8:00 AM in the northbound direction as motorists travel towards the southbound SR 167 ramps.

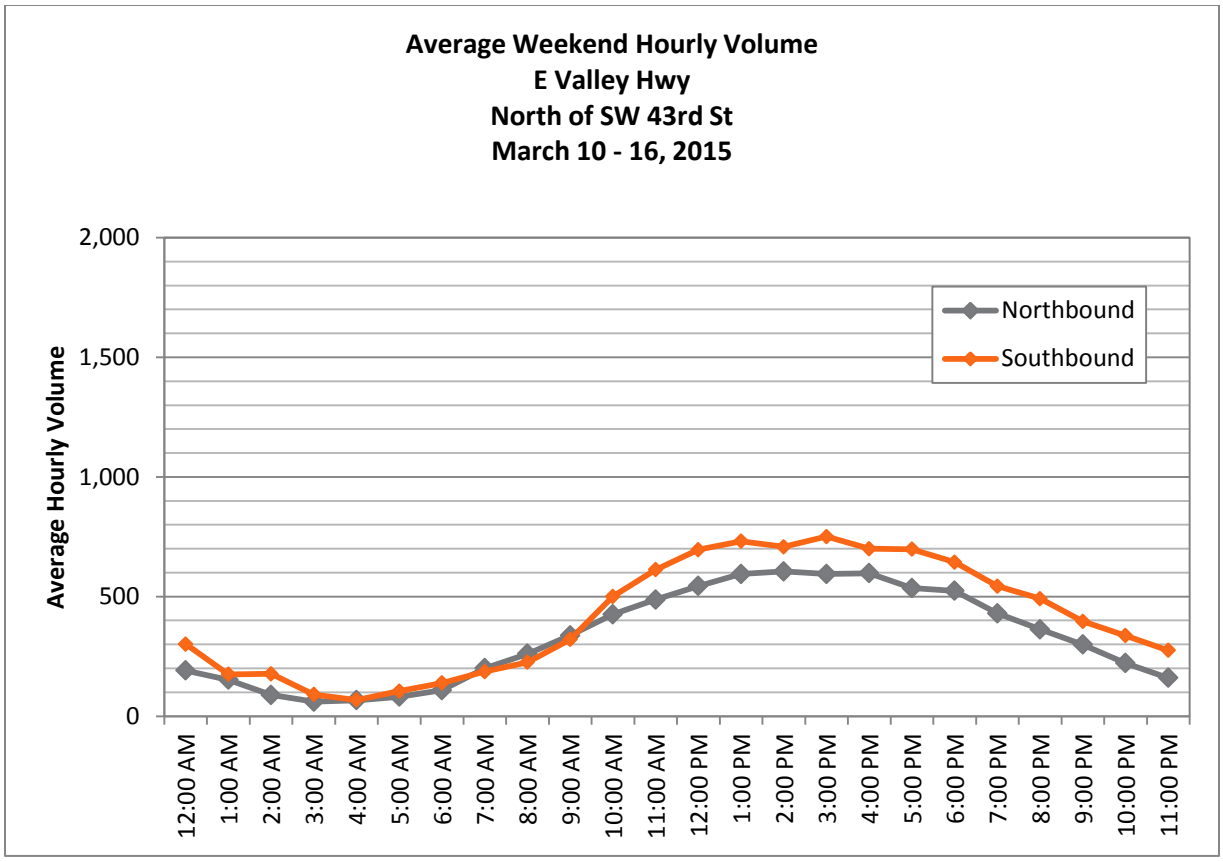


Figure 12 - E Valley Hwy Average Weekday Hourly Volume

Weekend traffic has very similar characteristics to the weekday hourly traffic with the exception of the AM commute peak in the northbound traffic. Traffic picks up in both directions around 10 AM, and remains fairly constant until 8:00 PM.

9.2 SR 167 Corridor

SR 167 is the main highway connecting the cities of Renton, Kent, Auburn, and other cities to the south up to the south end of Lake Washington and the I-5 and I-405 freeways. It has very heavy commuter influenced peaks for traffic. Traffic counts were taken at the SR 167 northbound off ramps at SW 43rd St.

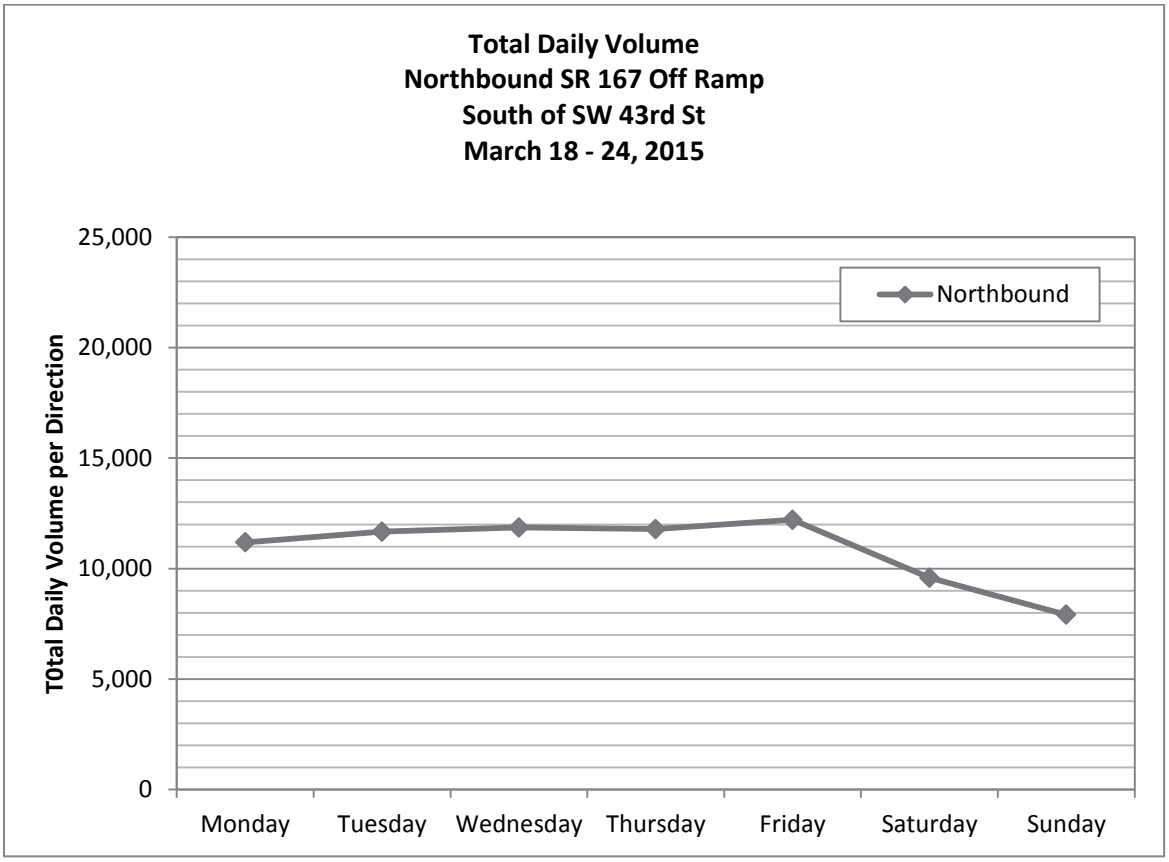


Figure 13 - SR 167 Off Ramp Total Daily Volume

A steady stream of vehicles exit onto SW 43rd St on weekdays. Traffic decreases by 20 – 35% on the weekends.

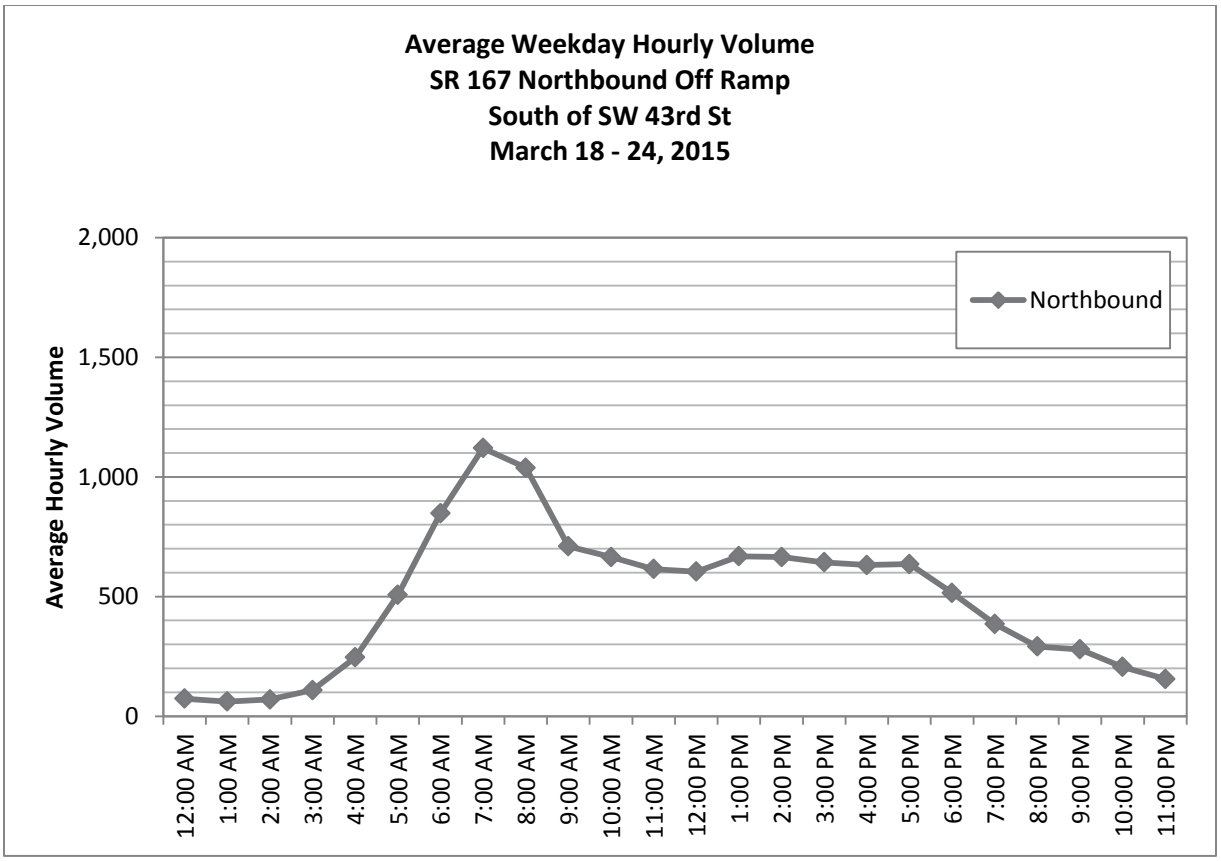


Figure 14 - SR 167 Northbound Off Ramp Average Weekday Hourly Volume

A substantial AM peak occurs around 7:00 AM for the off ramp reaching a peak of 1,100 vehicles per hour. Following the AM peak, traffic reduces to a steady 500 – 700 vehicles per hour until 5:00 PM. The AM peak represents a volume twice the size of the PM period.

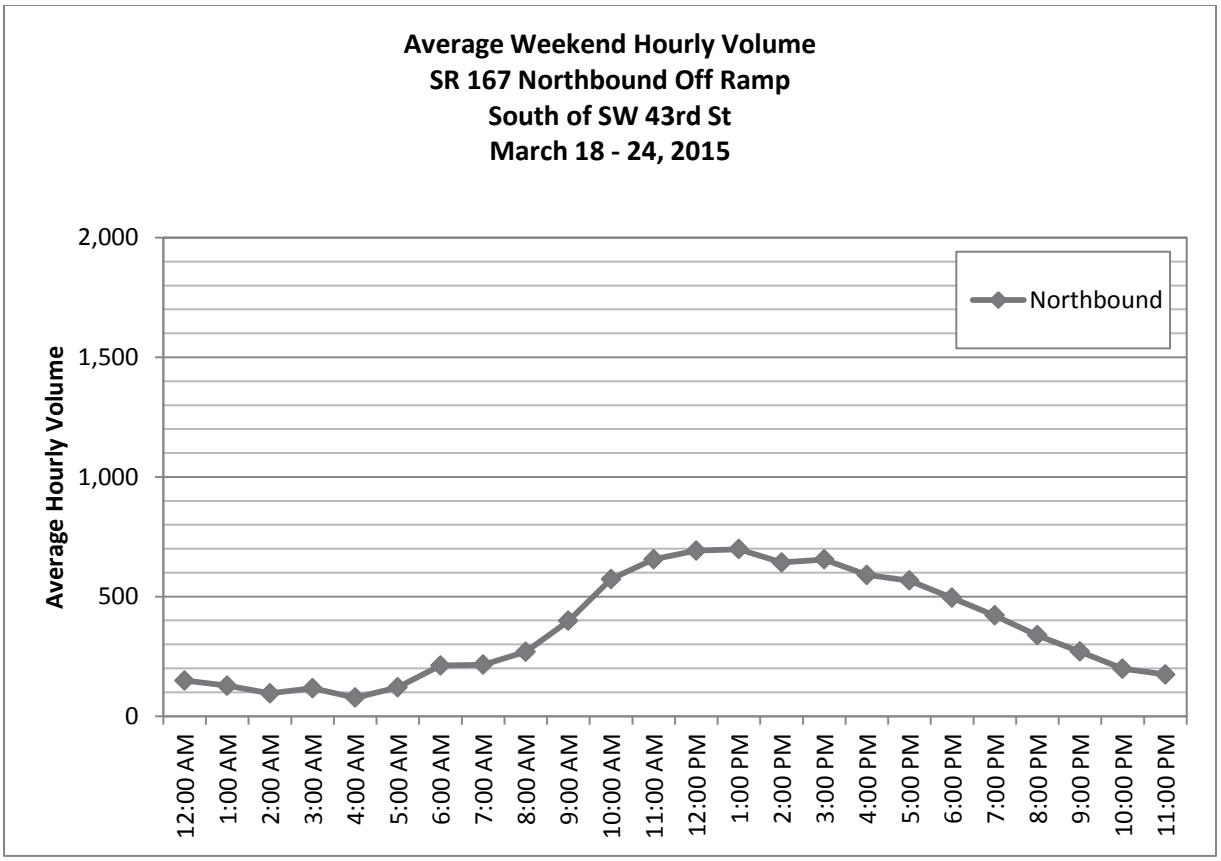


Figure 15 - SR 167 Northbound Off Ramp Average Weekend Hourly Volume

During the weekend, there is no specific peak period. Traffic volumes remain around 700 vehicles per hour for an 8 hour period beginning at 10:00 AM.

9.3 S Carr Rd (SW 43rd St) Corridor

S Carr Rd is a major connection between SR 515 and SR 167. The volumes on this corridor are very high and variable. The following figures display the traffic counts along the corridor. Traffic counts were taken just east of the SR 167 northbound ramps.

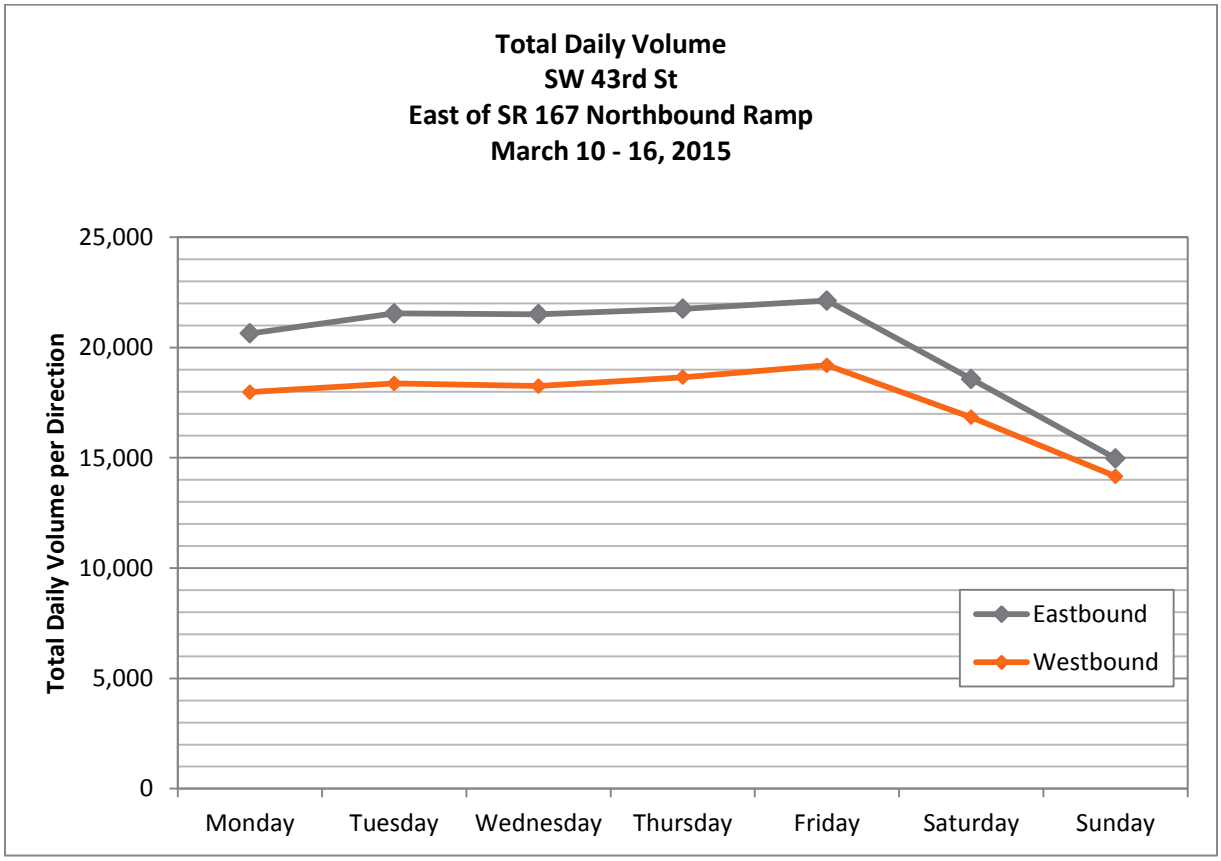


Figure 16 - SW 43rd St Total Daily Volume

As expected, the volumes are very high throughout the week. During the weekend, volumes decrease but remain above 14,000 vehicles in each direction each day. The volumes of this corridor demand greater attention in order to manage them effectively.

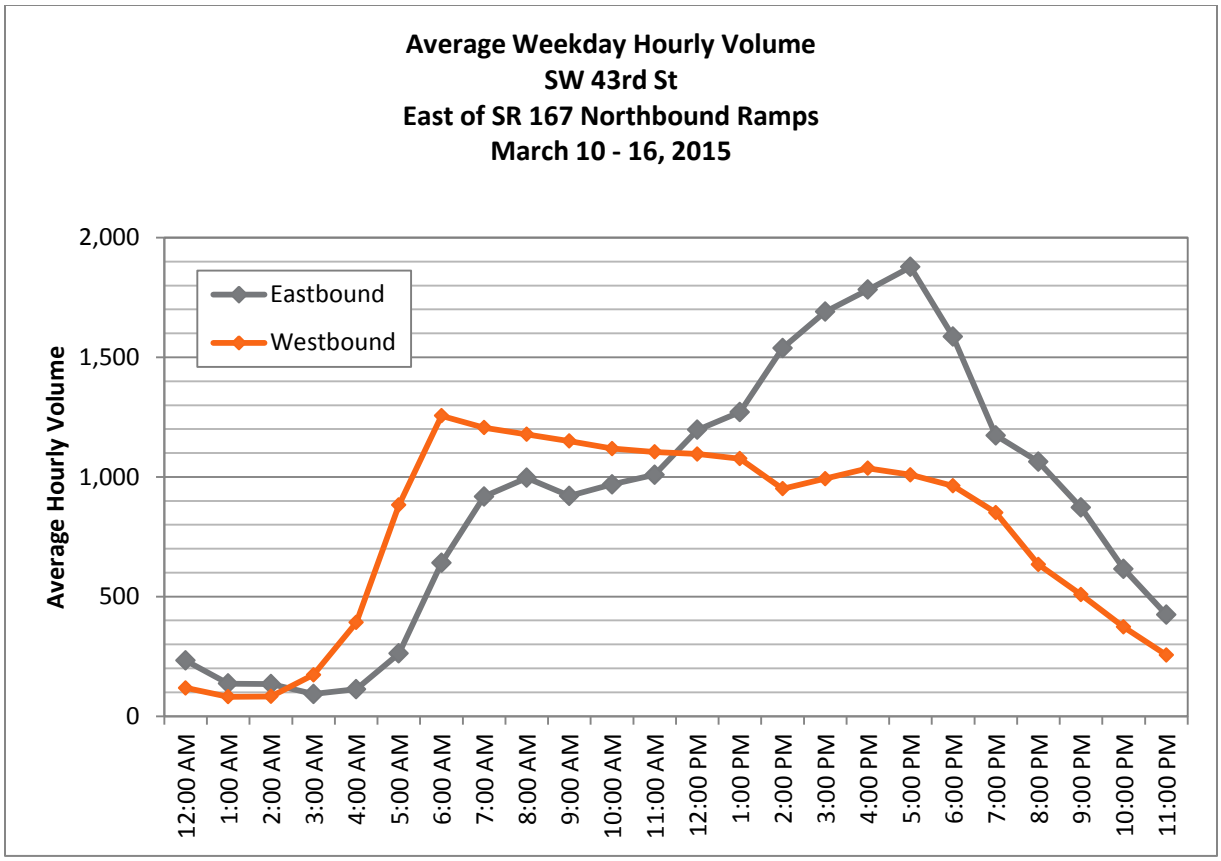


Figure 17 - SW 43rd St Average Weekday Hourly Volume

The westbound has a strong peak in the AM period around 6:00 AM. These volumes are generated from commute traffic traveling towards SR 167 northbound. Eastbound experiences a very minor AM peak and a much more significant PM peak for commuters heading home starting at 2:00 PM and lasting until 7:00 PM. This long period of high volume leads to increased delay in motorists attempting to access SR 515 from SR 167.

During field observations, it was noted that the northbound ramp signals caused a high delay at the northbound SR 167 half interchange. This delay from the ramp signals created an intersection delay at the SR 167 half interchange. Queues extended past 98th Ave S in the westbound direction and past E Valley Hwy in the eastbound direction. Figure 18 provides a snapshot of typical weekday afternoon traffic at 4 pm. This queue creates significant delays for the Carr Rd corridor in addition to its access to northbound SR 167.

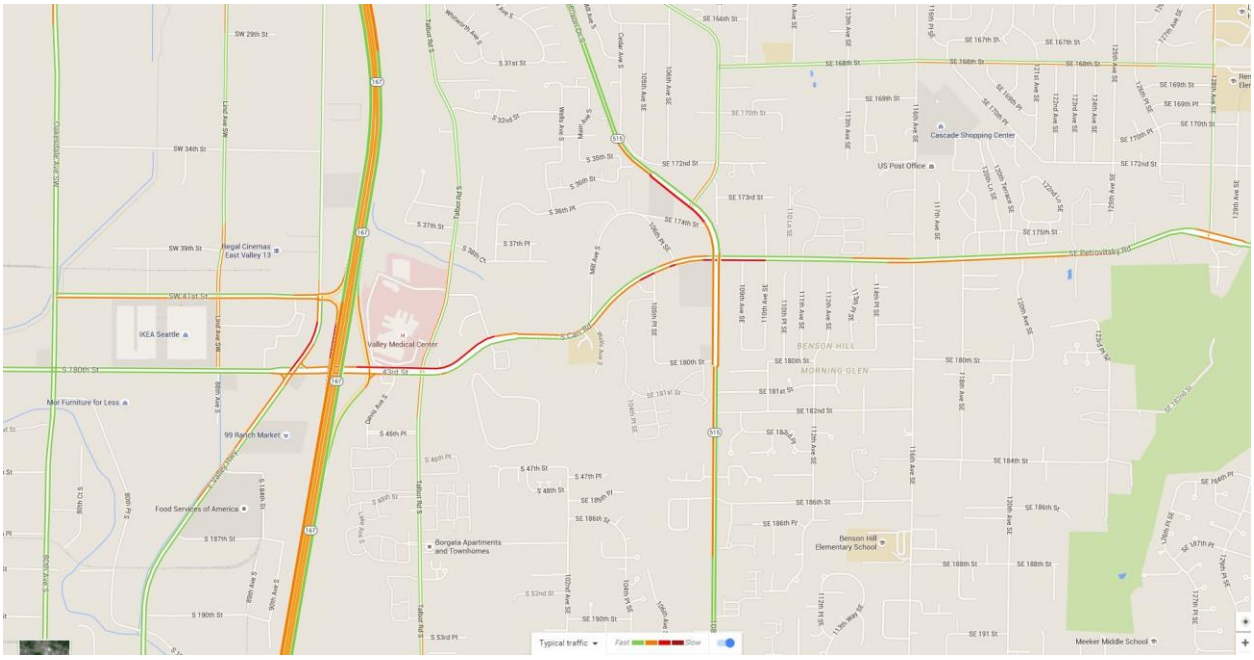


Figure 18 - Typical Weekday PM Traffic (Source: Google Maps Analytics)

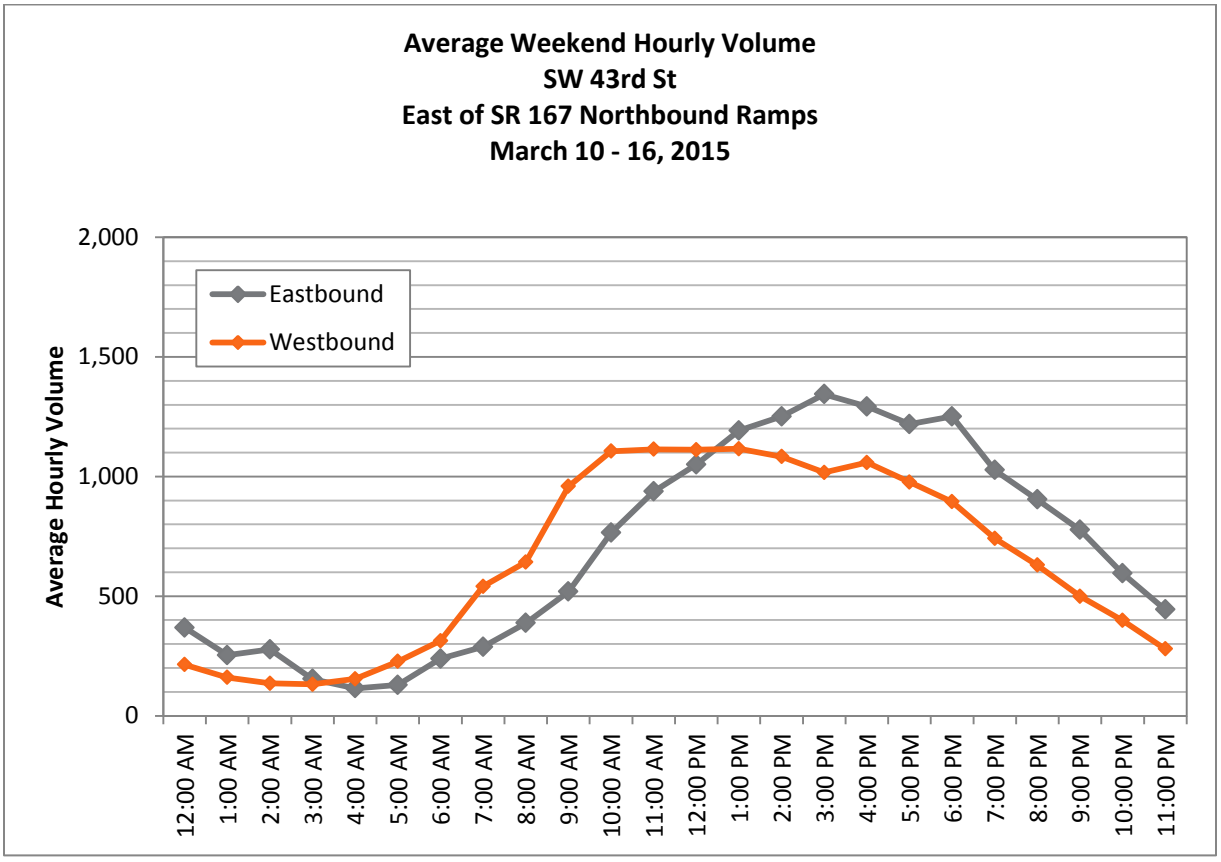


Figure 19 - SW 43RD St Average Weekend Hourly Volume

Both directions increase in volume with a peak of 3:00 PM for the eastbound traffic. Westbound peak remains constant at around 1,100 vehicles per hour for most of the day.

9.4 S Carr Rd Corridor (SE Petrovitsky Rd)

S Carr Rd east of SR 515 is named SE Petrovitsky Rd. Traffic along this corridor is traveling to and from both SR 167 and SR 515.

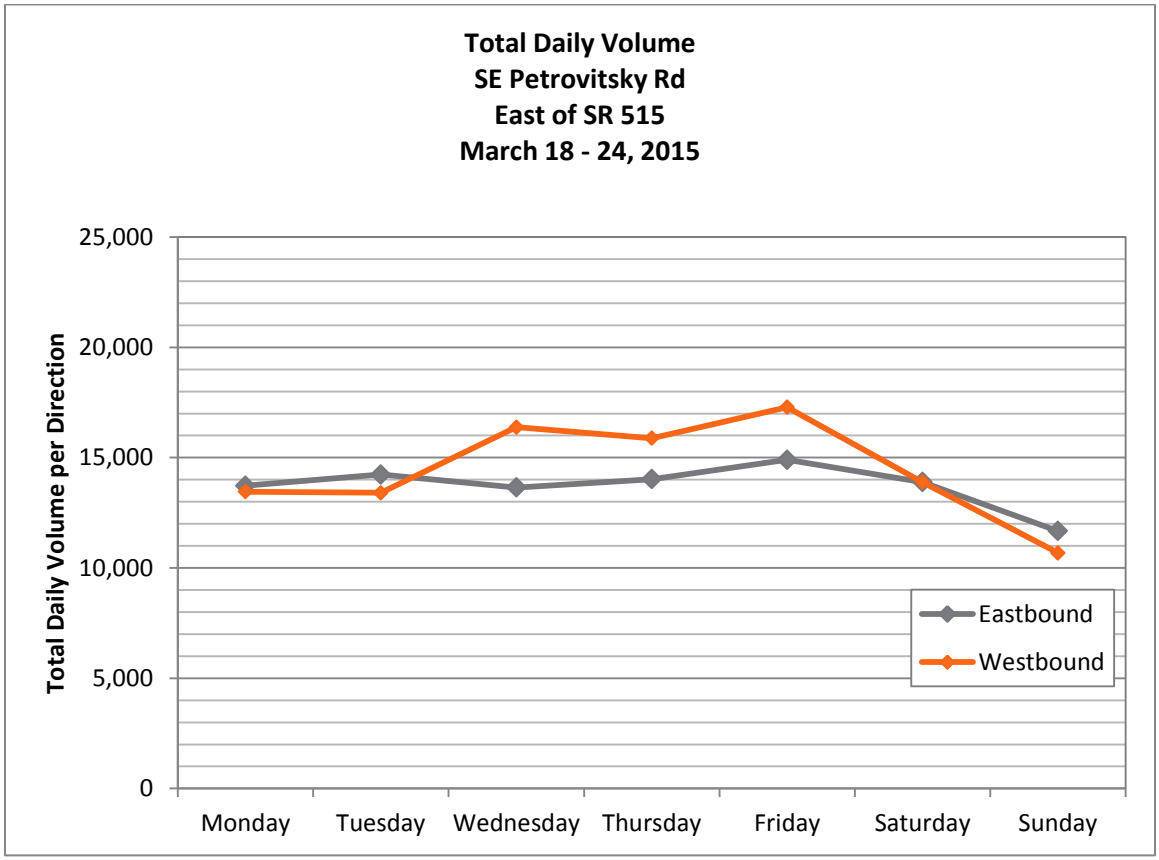


Figure 20 - SE Petrovitsky Rd Total Daily Volume

On SE Petrovitsky Rd there is variability in the westbound direction. During the weekdays, the total number of vehicles per day varies up to 4,000. Traffic becomes heavier later in the week.

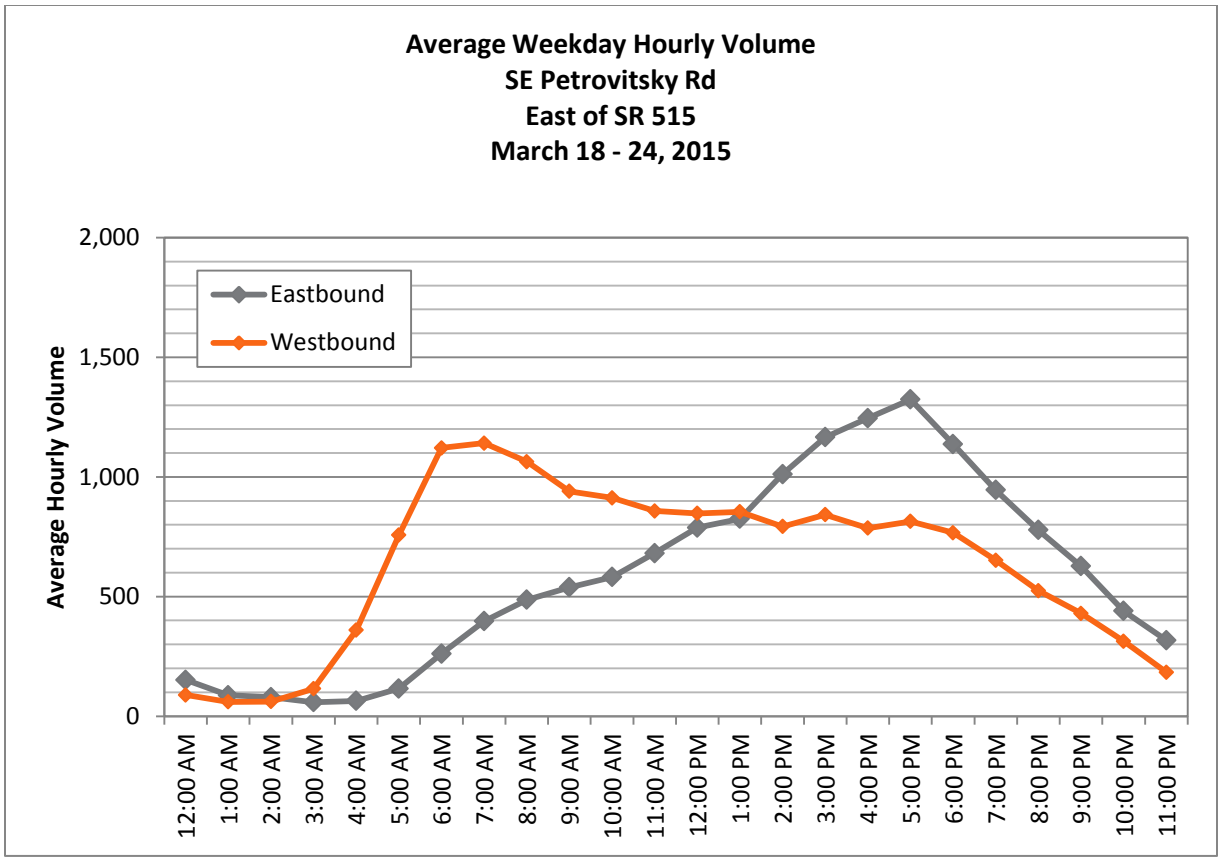


Figure 21 - SE Petrovitsky Rd Average Weekday Hourly Volume

There are two distinct peak periods on SE Petrovitsky Rd. During the AM, a peak occurs westbound between 6:00 AM – 8:00 AM. This is mimicked in the eastbound direction with a slightly higher peak between 4:00 PM – 6:00 PM.

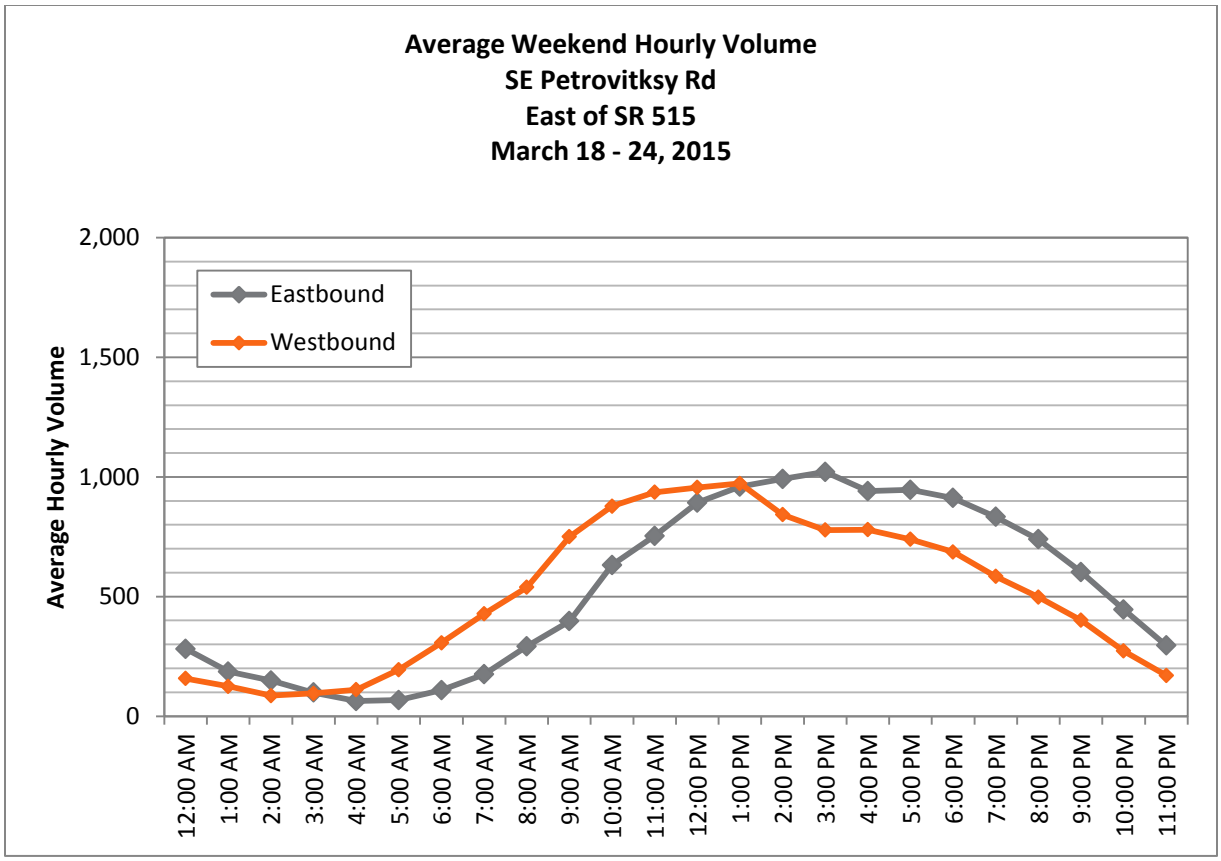


Figure 22 - SE Petrovitsky Rd Average Weekend Hourly Volume

During the weekends, traffic behaves similar to other area locations. The westbound direction increases in volume about two hours ahead of the eastbound. Each remains steady for a period of about 7 hours, hovering between 750 and 1000 vehicles per hour per direction.

9.5 SR 515 Corridor

SR 515 is a main north-south arterial for commuting traffic that parallels SR 167. The following figures display the traffic counts along the corridor. Counts on SR 515 were taken just south of the S Carr Rd corridor.

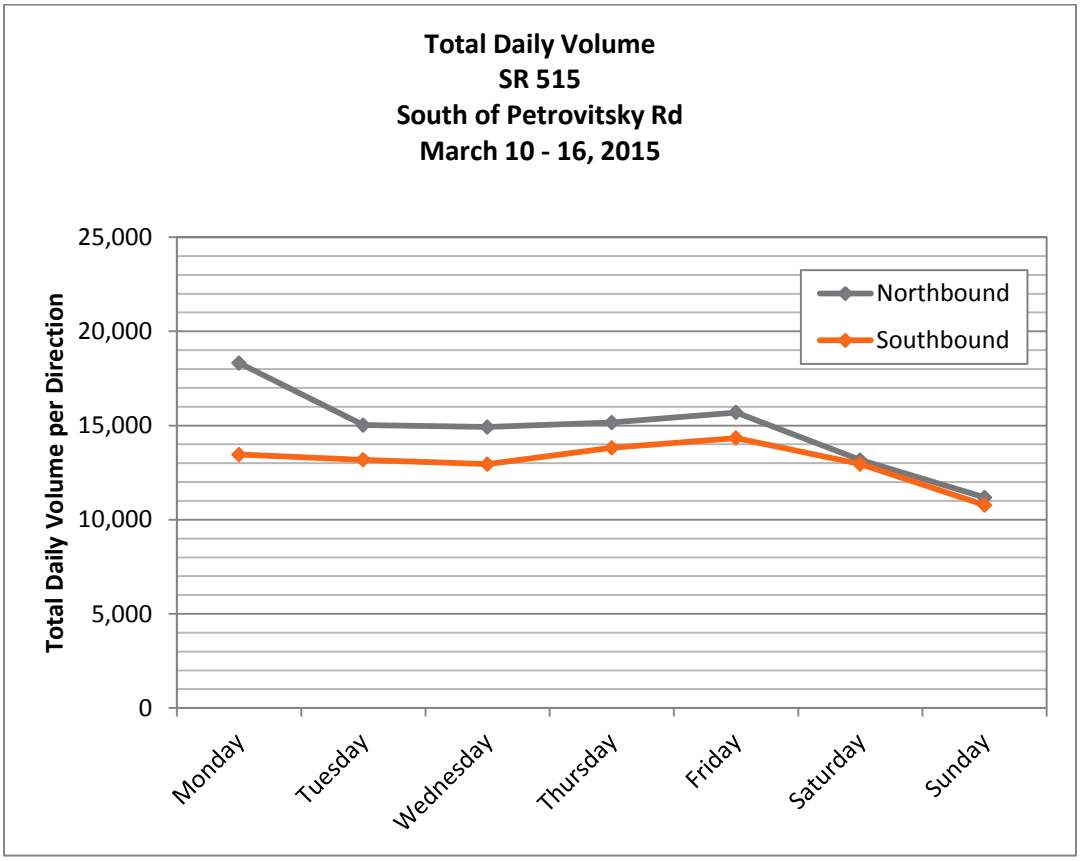


Figure 23 - SR 515 Total Daily Volume

The total volume along SR 515 is generally higher in the northbound direction. Volumes on Saturdays are only slightly lower than the weekday volumes. On the weekends, the disparity between volumes in each direction becomes much smaller.

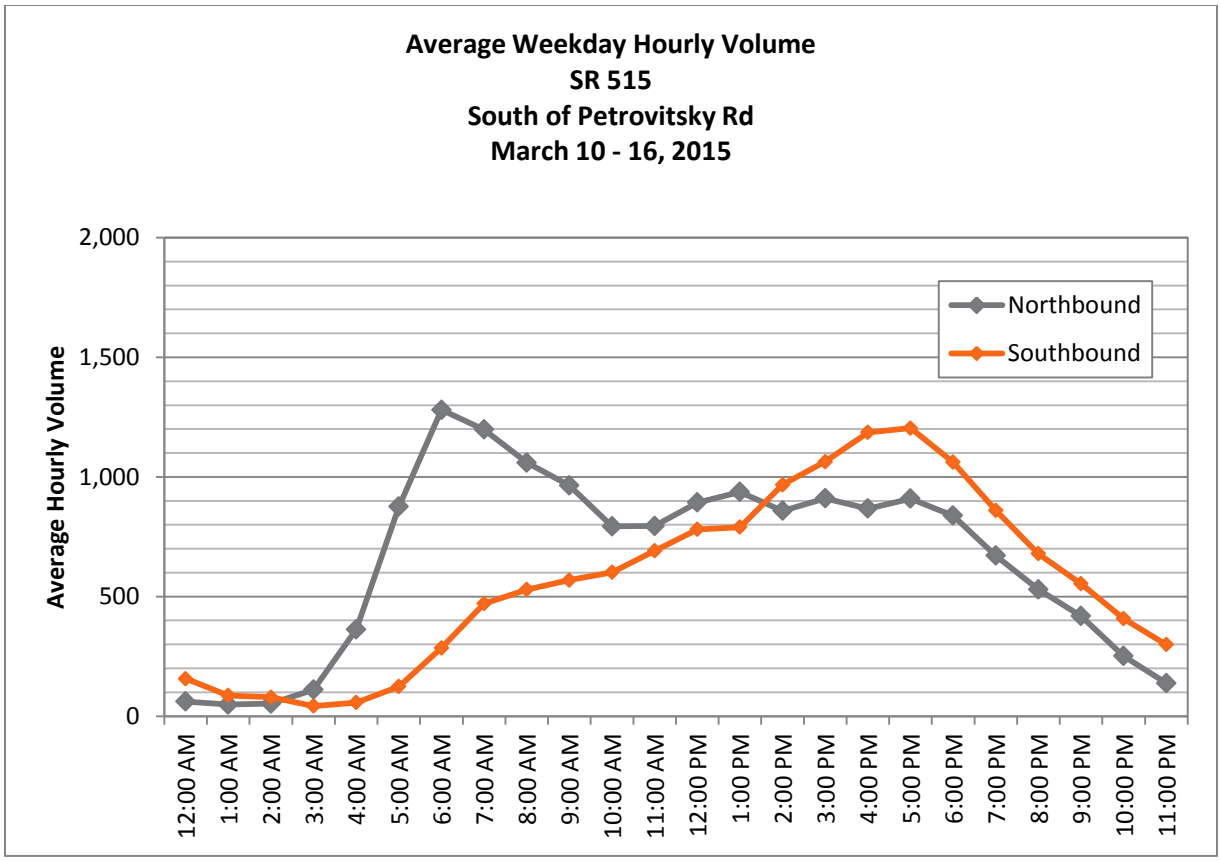


Figure 24 – SR 515 Average Weekday Hourly Volume

The AM peak period in the northbound direction occurs around 6:00 AM. Following the AM peak, volumes dip but remain steady during most of the day. The southbound direction does not experience an AM peak period; rather, the volume increases steadily throughout the day before reaching a PM peak between 4:00 PM – 6:00 PM.

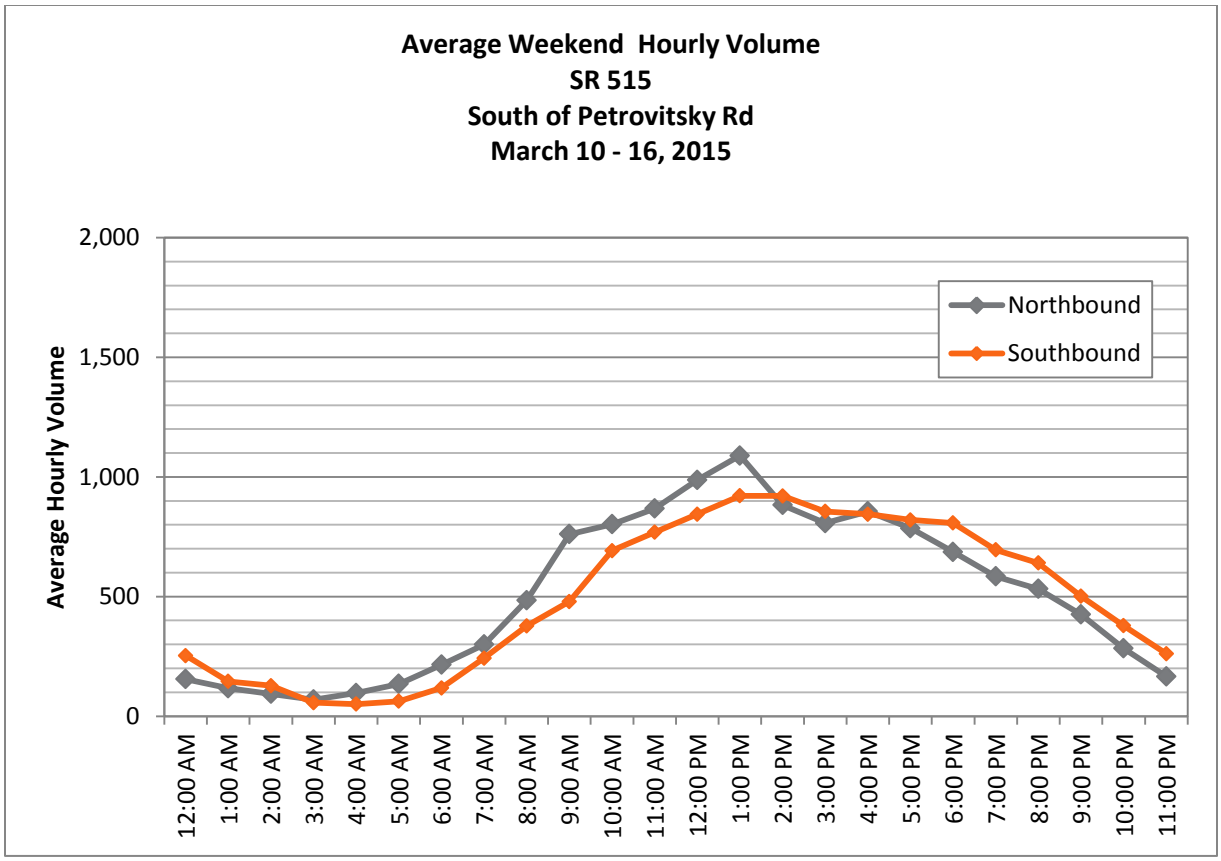


Figure 25 - SR 515 Average Weekend Hourly Volume

During the weekends there is a steady rise in volume beginning around 7:00 AM and with a peak around 1:00 PM. This remains moderate throughout the day.

10 Appendix B – Intersection Loop Detection Schematics

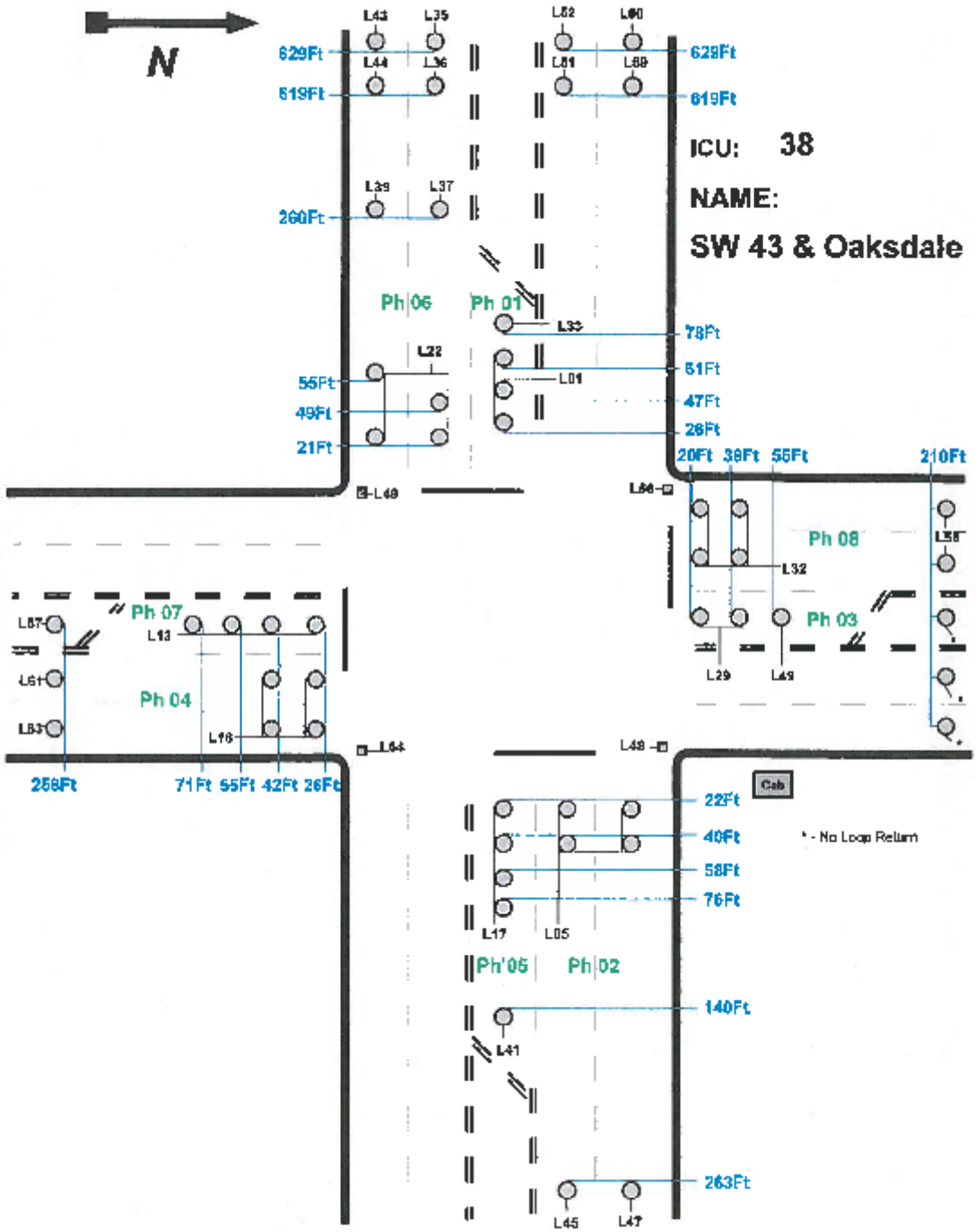


Figure 26 - SW 43rd St & Oakesdale Ave SW Loop Detection Schematic

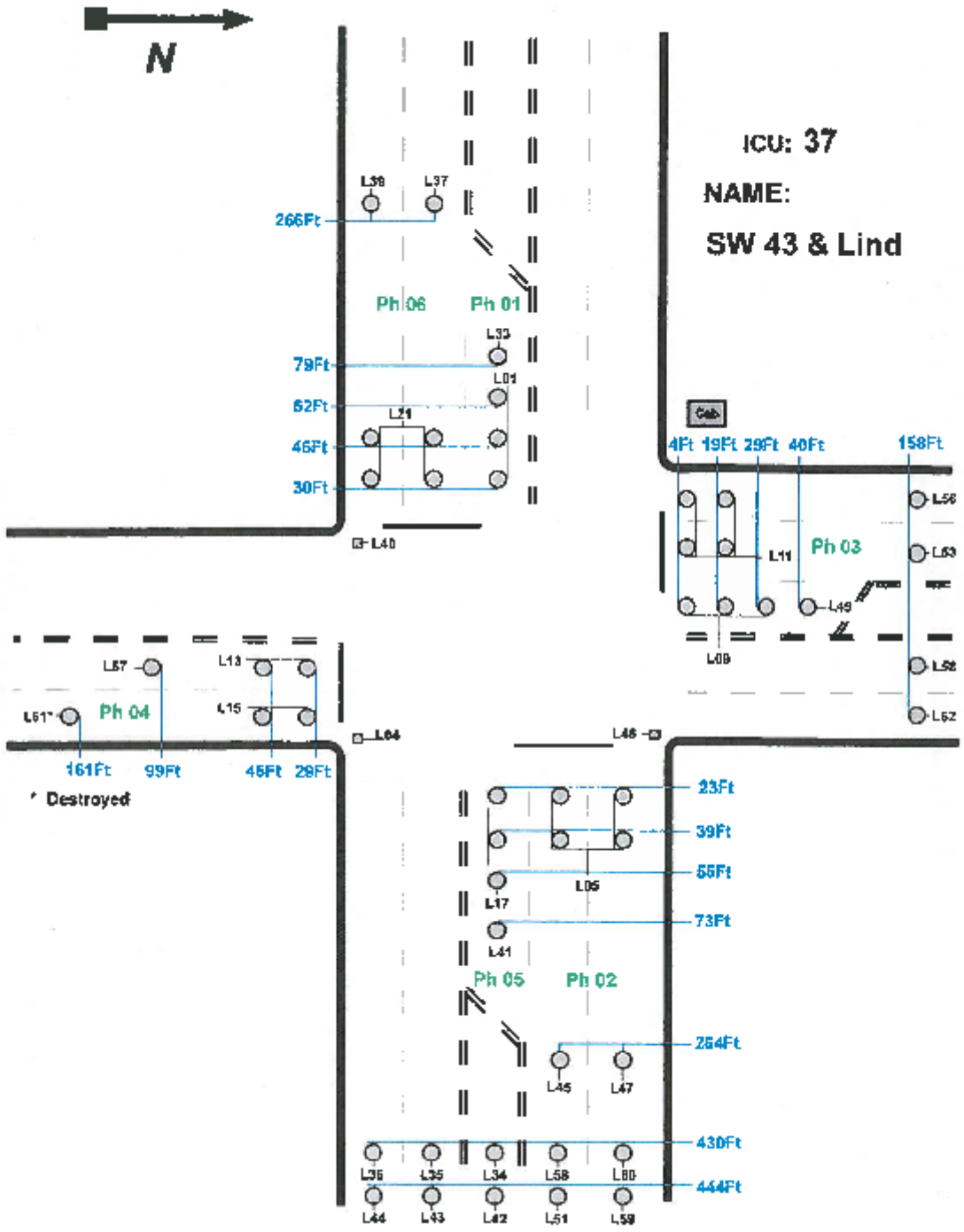


Figure 27 - SW 43rd St & Lind Ave S Loop Detection Schematic

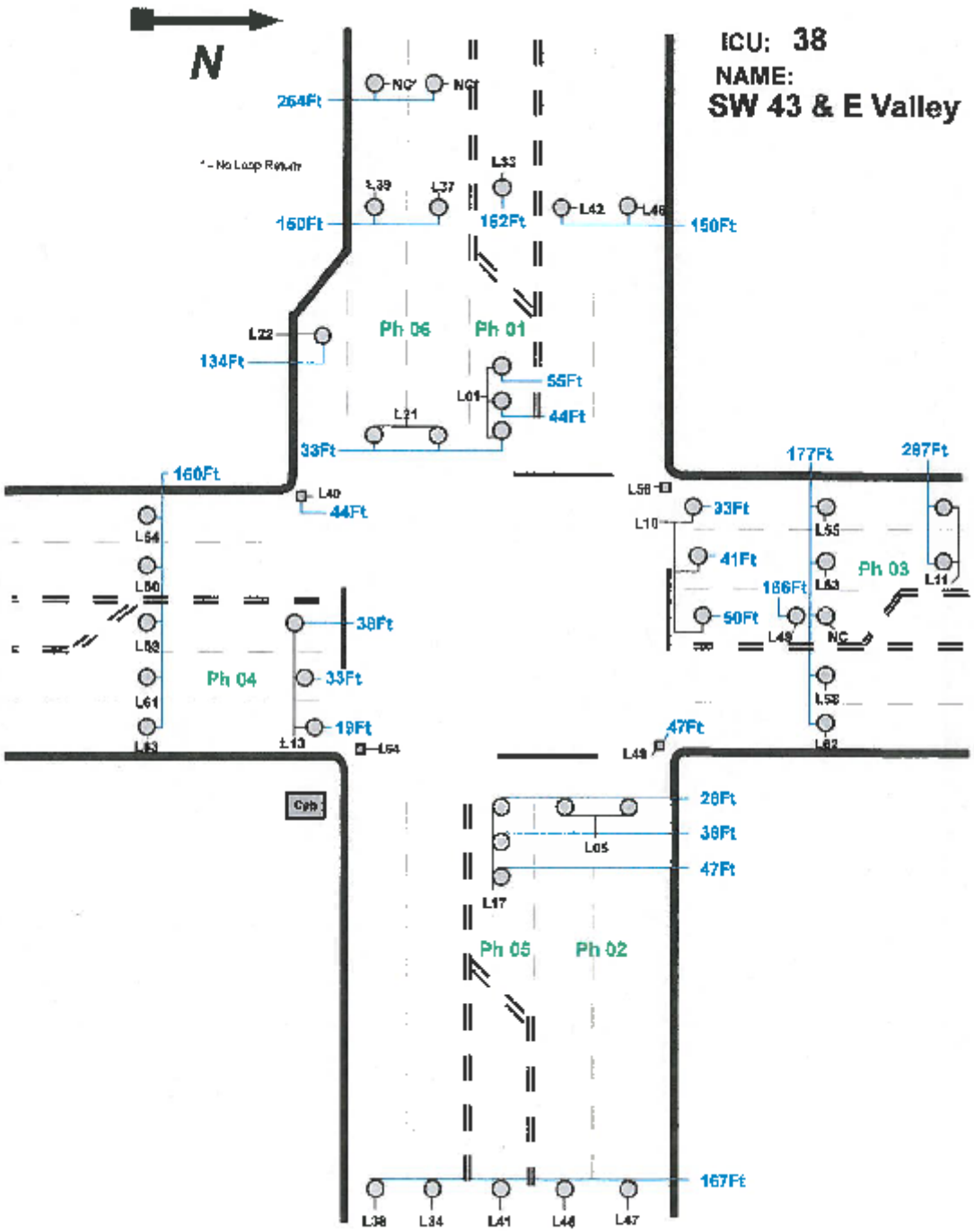


Figure 28 - SW 43rd St & E Valley Hwy Loop Detection Schematic

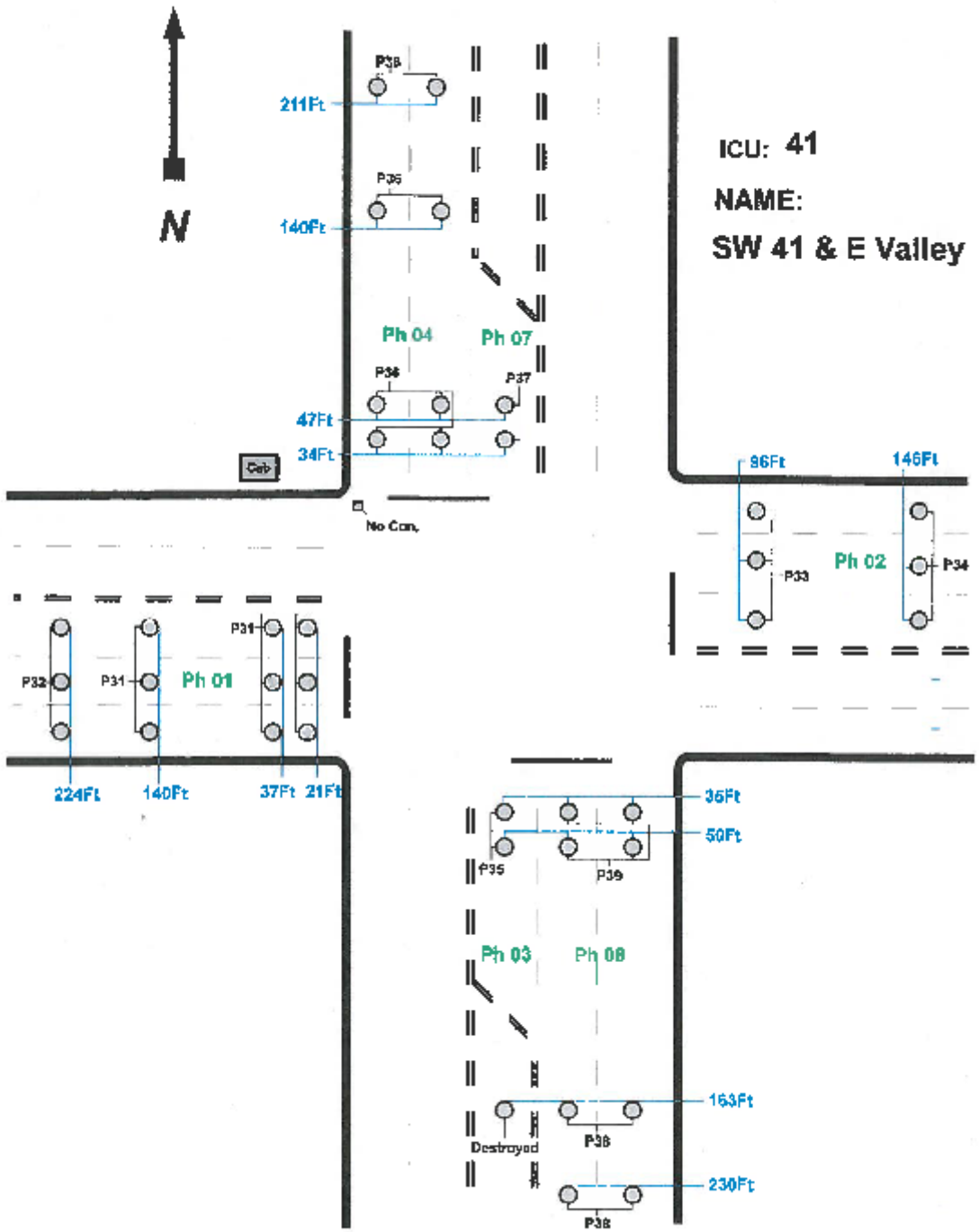


Figure 29 - SW 41st S (SR 167 Southbound Ramps) & E Valley Hwy Loop Detection Schematic

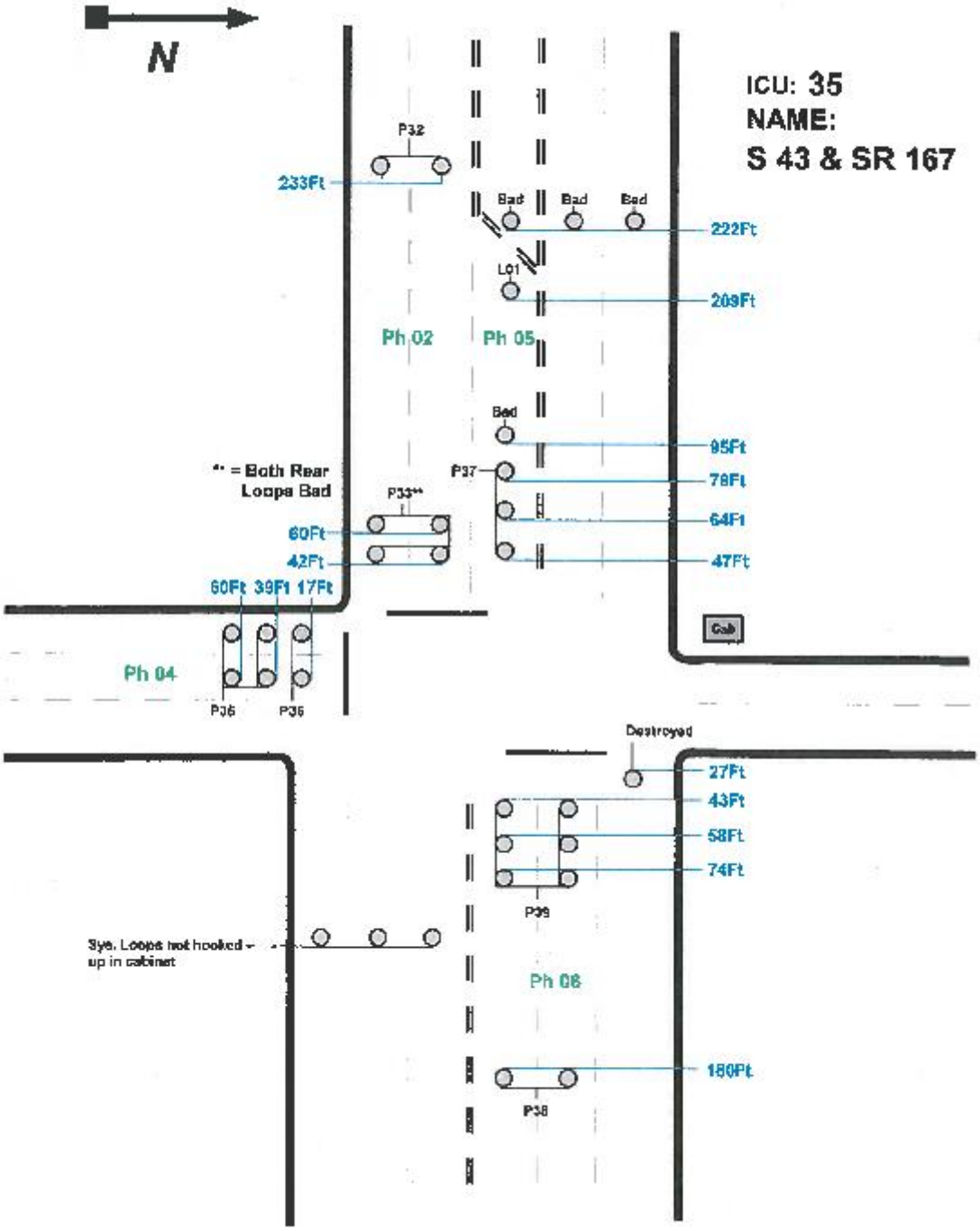


Figure 30 - SW 43rd St & SR 167 Northbound Ramps Loop Detection Schematic

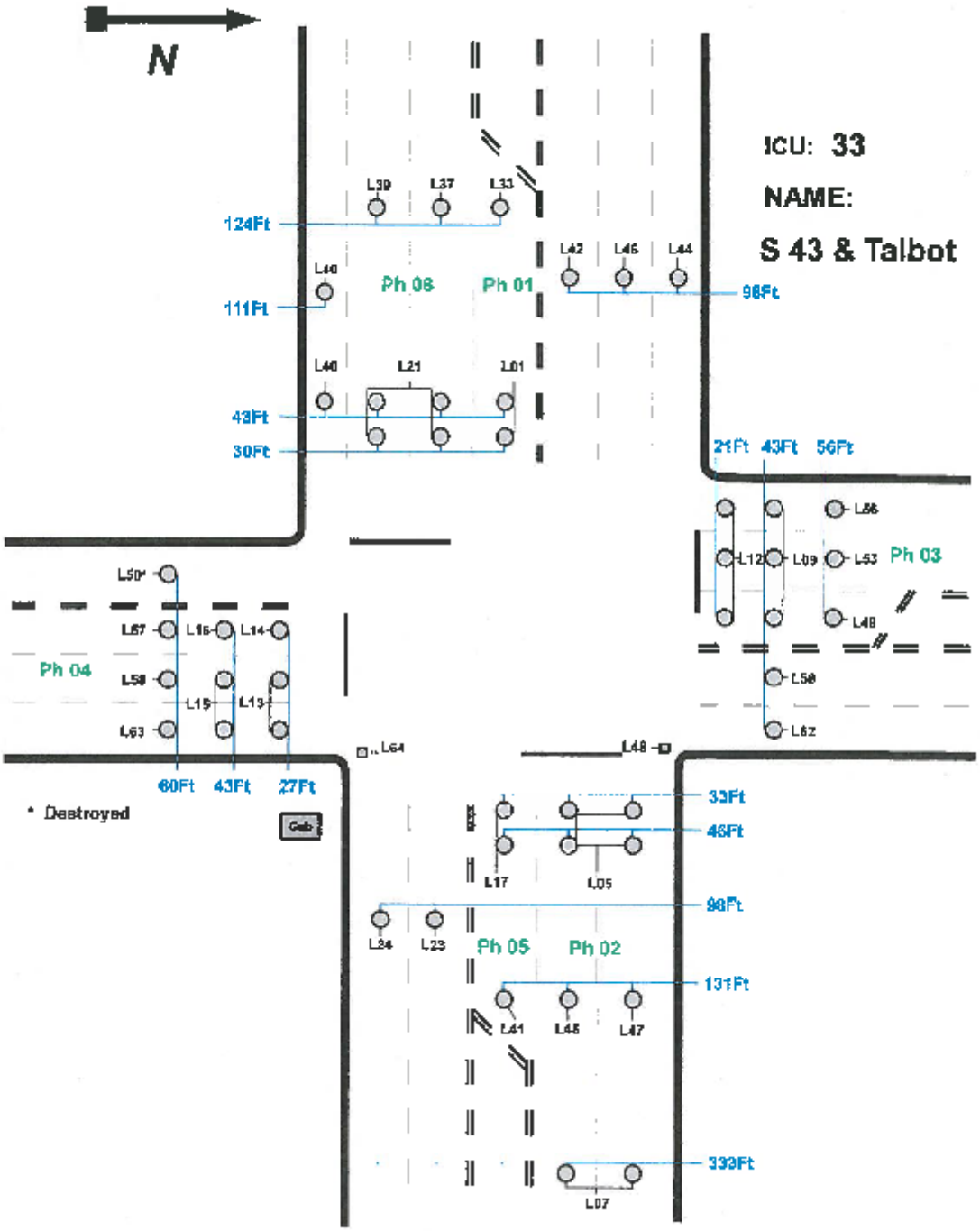


Figure 31 - SW 43rd St & Talbot Rd S Loop Detection Schematic

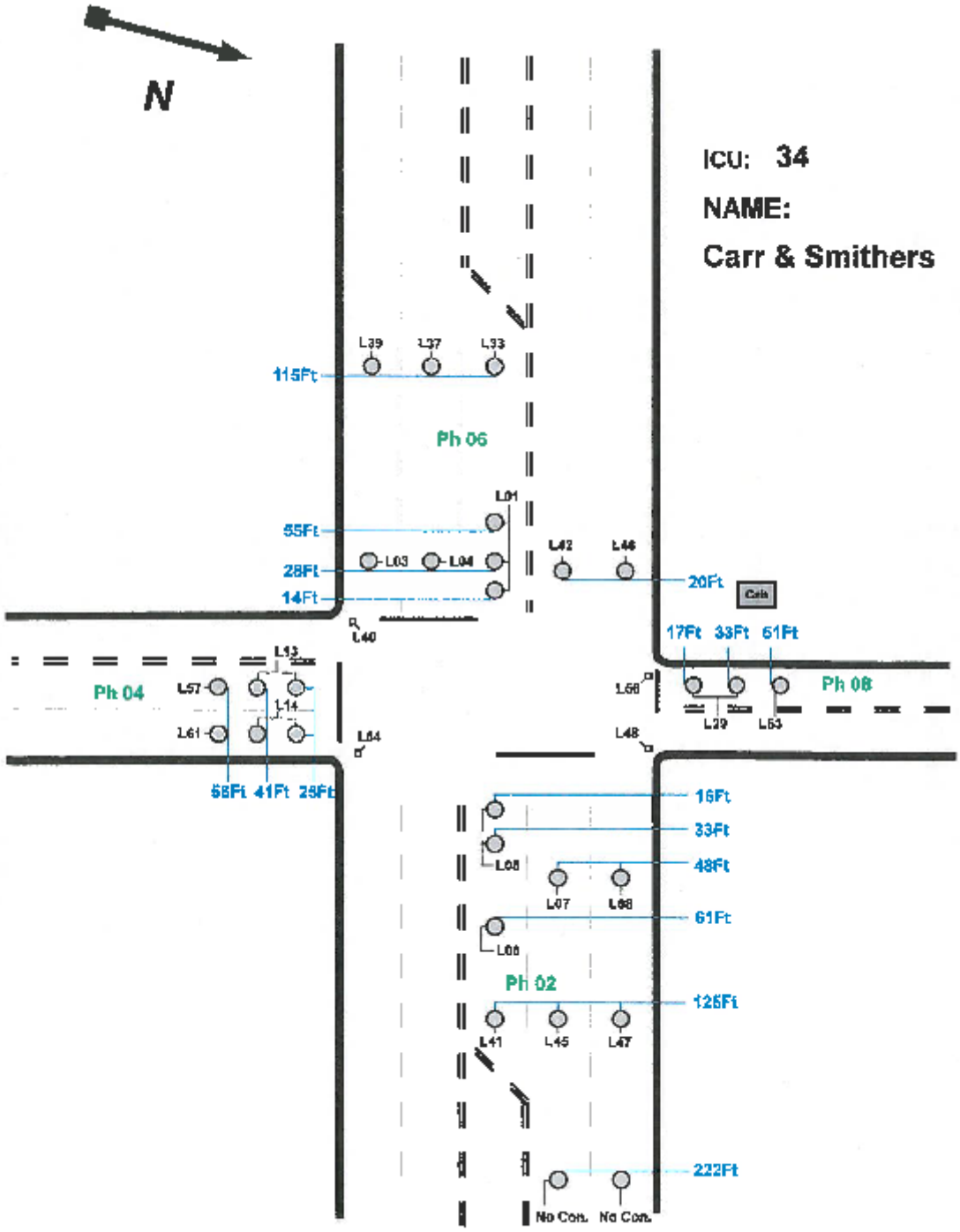


Figure 32 - SE Carr Rd & 98th Ave S (Smithers Ave) Loop Detection Schematic

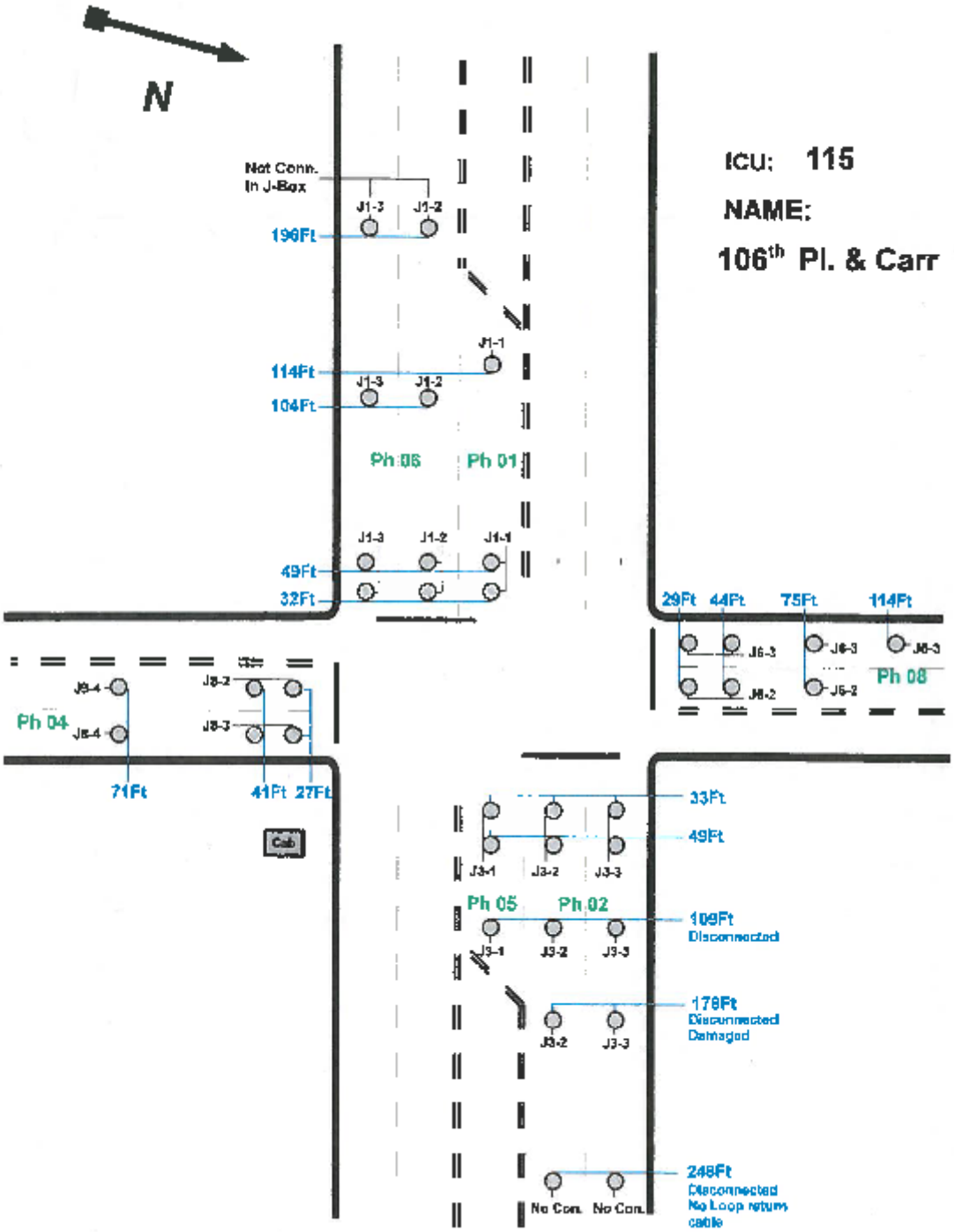


Figure 33 - SE Carr Rd & 106th Pl SE

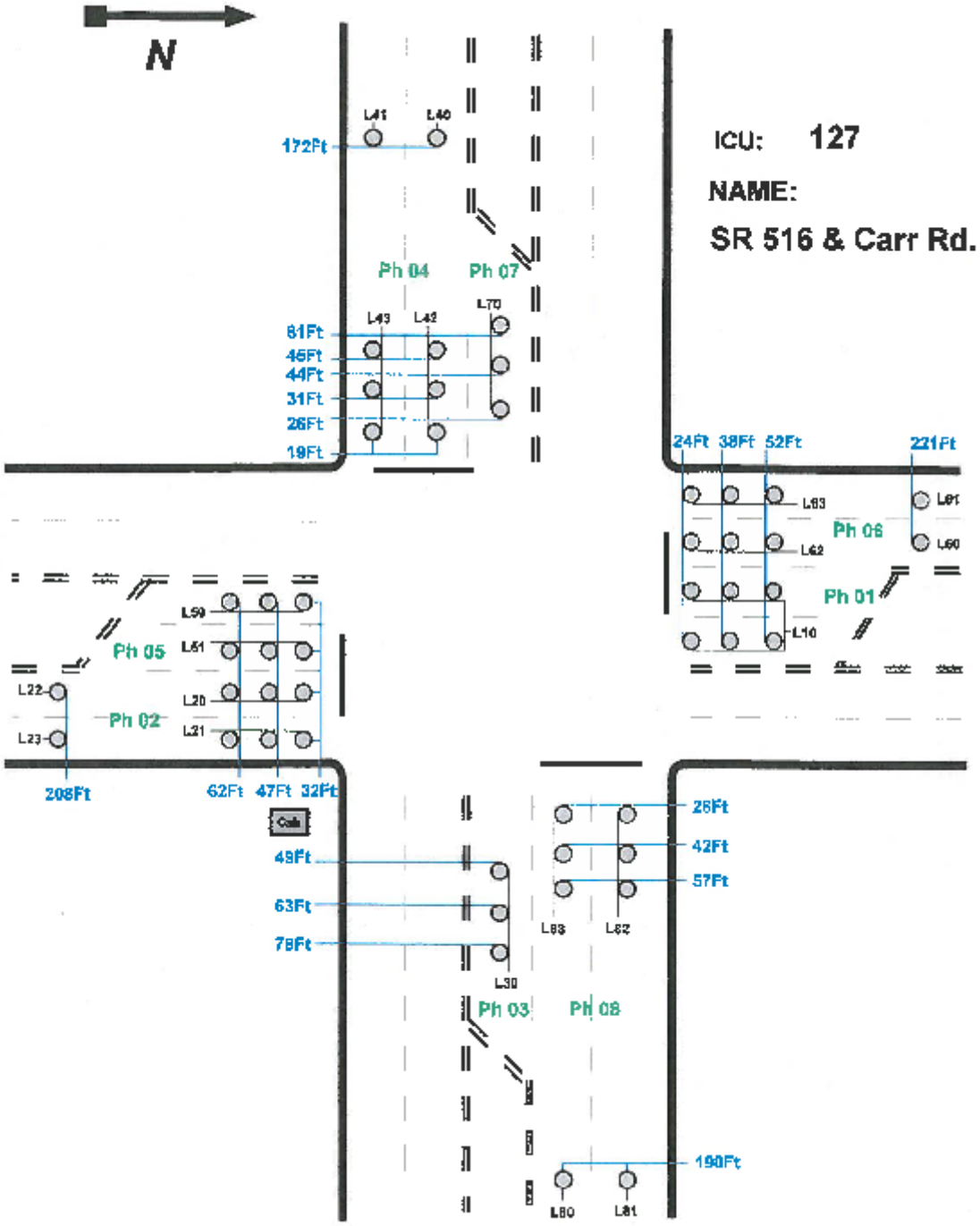


Figure 34 - SE Petrovitsky Rd & SR 515 Loop Detection Schematic

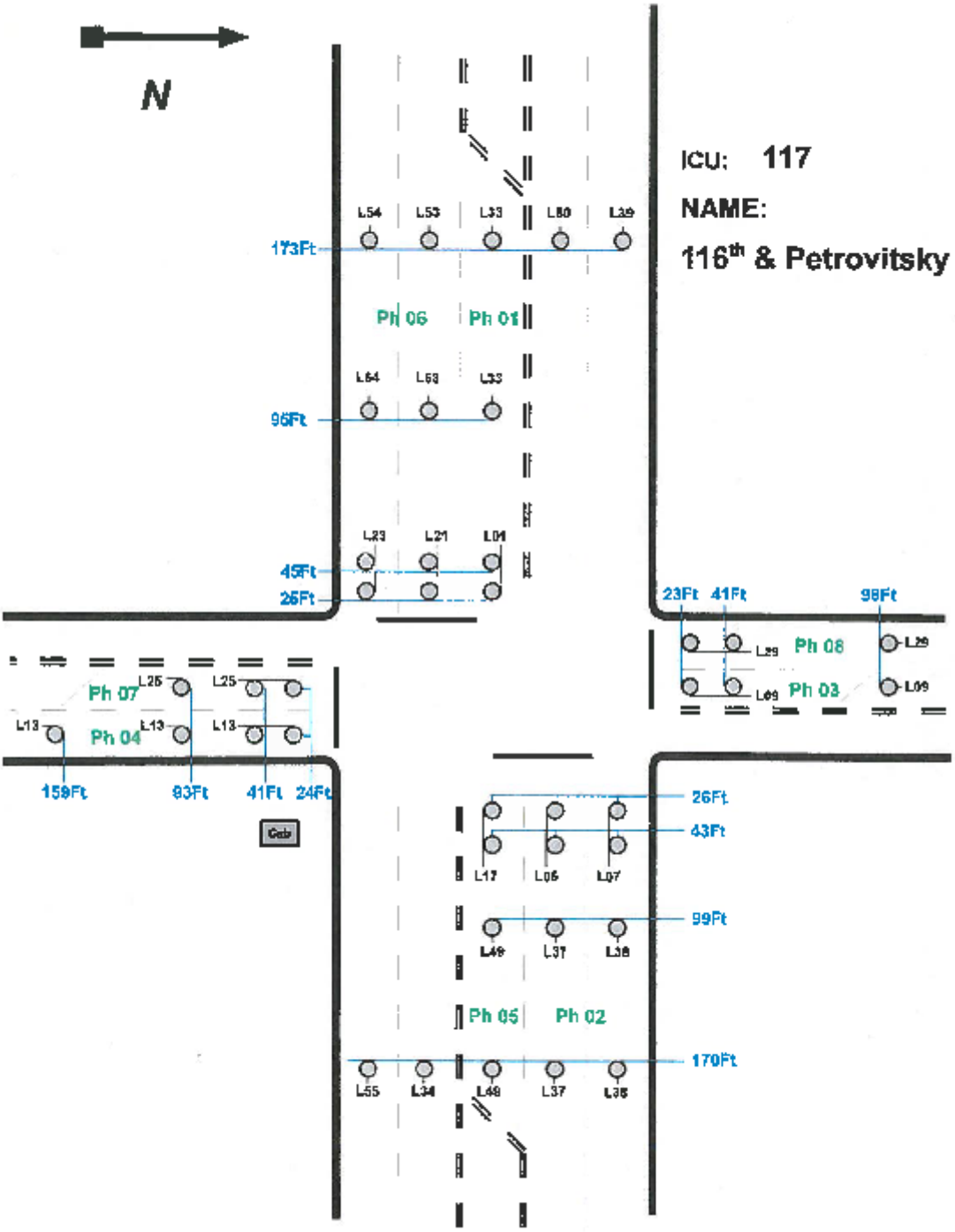


Figure 35 - SE Petrovitsky Rd & 116th Ave SE Loop Detection Schematic

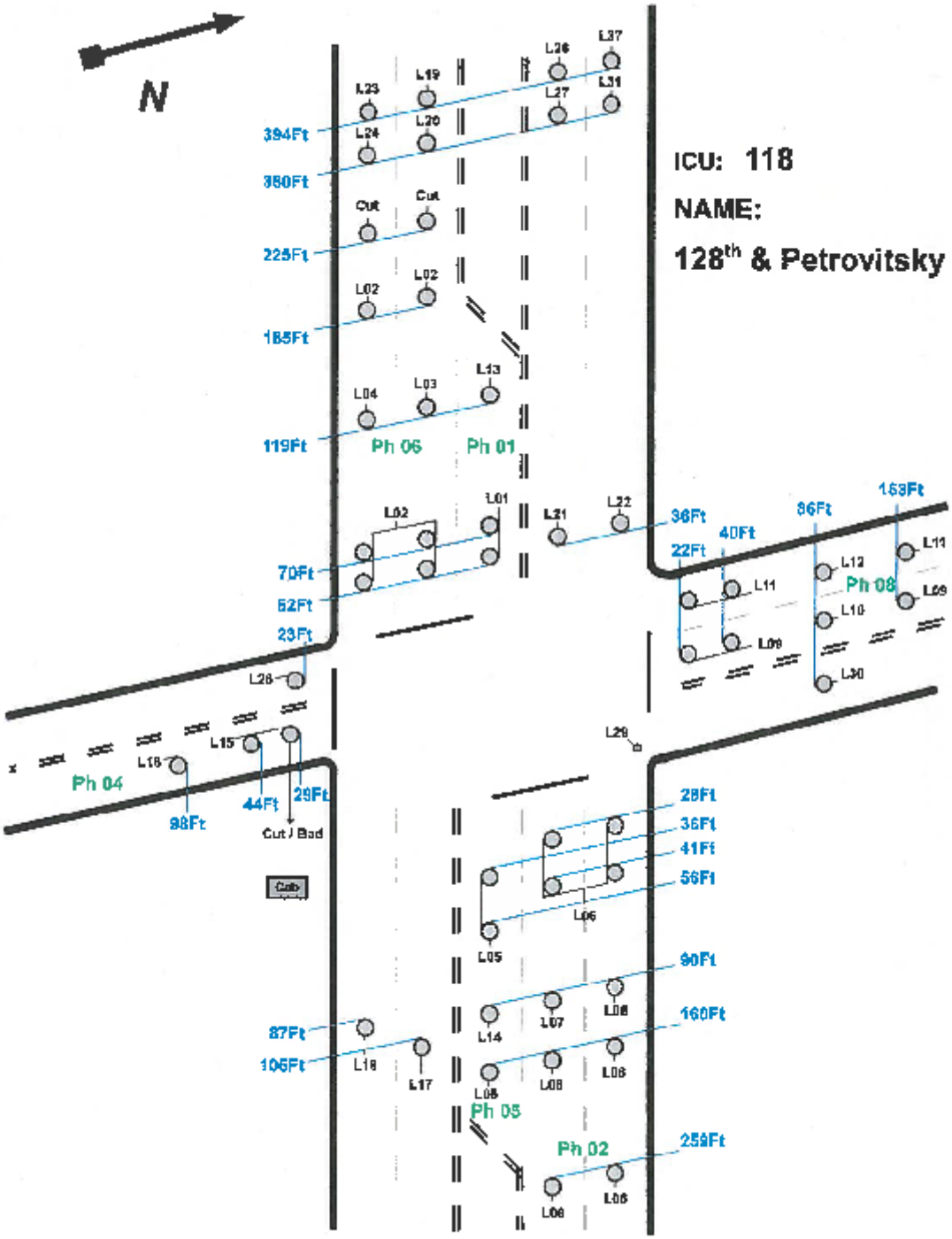


Figure 36 - SE Petrovitsky Rd & 128th Ave SE Loop Detection Schematic

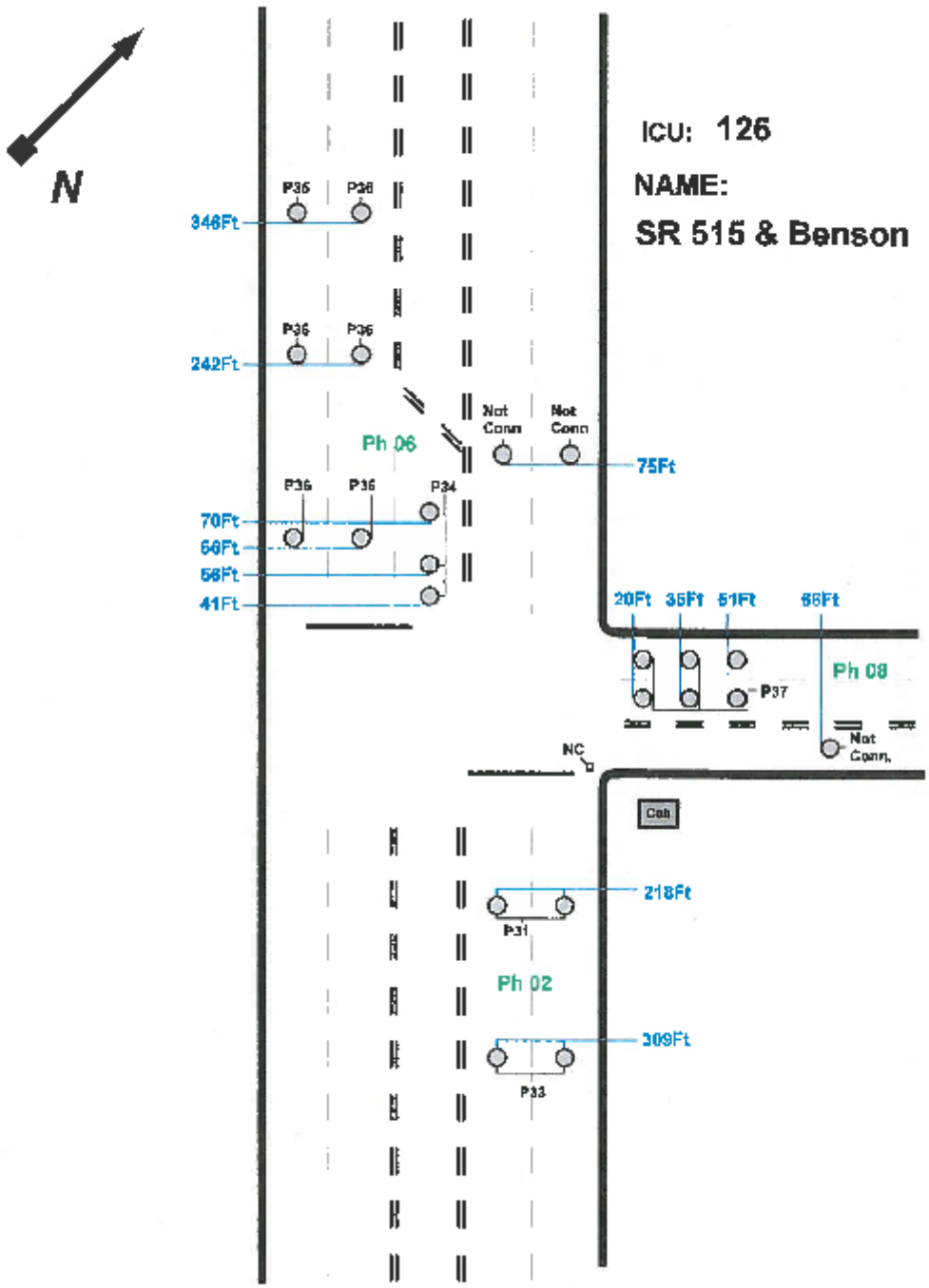


Figure 37 - Benson Rd & SR 515 Loop Detection Schematic

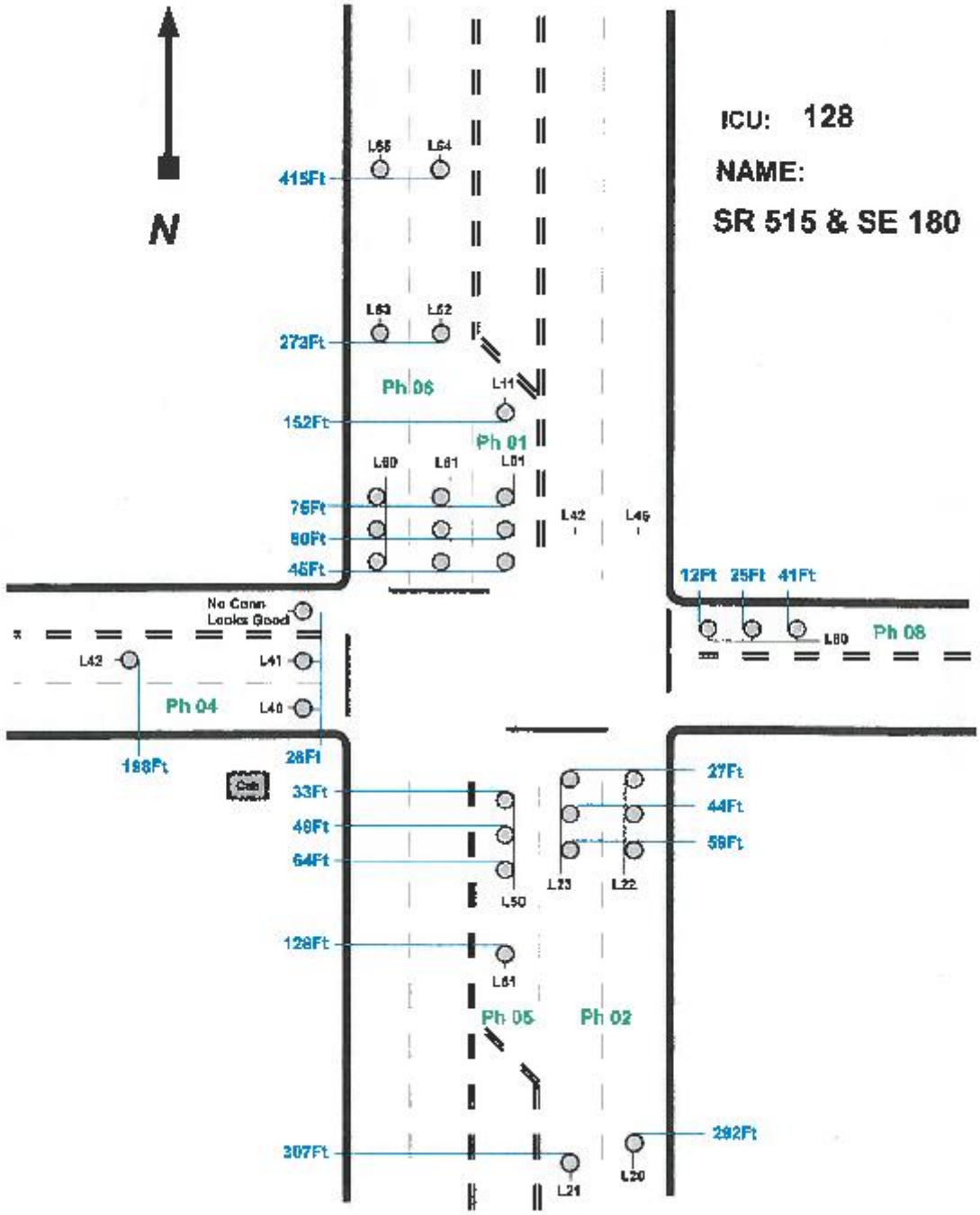


Figure 38 - SE 180th St & SR 515 Loop Detection Schematic

Appendix B: System Requirement Matrix

City of Renton SW 43rd Street/Carr Road/Petrovitsky Road
Adaptive Signal Control Technology
System Requirements
December 2015

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
1	**1 Network Characteristics**							
1.0-1	The ASCT shall control a minimum of 14 signals concurrently	4.2-1 The system operator needs to eventually adaptively control up to 13 signals, up to 10 miles from the TMC. Possible future expansion could increase the number of signals to 14.						Highly Desirable
1.0-2	The ASCT shall support groups of signals.	4.2-2 The system operator needs to be able to adaptively control up to 4 independent groups of signals 4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.						Highly Desirable
1.0-2.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	4.2-2 The system operator needs to be able to adaptively control up to 4 independent groups of signals						Highly Desirable
1.0-2.0-2	The ASCT shall control a minimum of 4 groups of signals.	4.2-2 The system operator needs to be able to adaptively control up to 4 independent groups of signals						Highly Desirable
1.0-2.0-3	The size of a group shall range from 1 to 7 signals.	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
1.0-2.0-4	Each group shall operate independently	4.2-2 The system operator needs to be able to adaptively control up to 20 independent groups of signals						Highly Desirable
1.0-2.0-5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the ASCT system according to configured parameters.	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.						Desirable
1.0-2.0-5.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to a time of day schedule. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.						Desirable
1.0-2.0-5.0-2	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to traffic conditions. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.						Desirable
1.0-2.0-5.0-3	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.						Desirable
2	**2 Type of Operation**							
2.1	**2.1 General**							
2.1.1	**2.1.1 Mode of Operation**							
2.1.1.0-2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	4.7-1 The system operator needs to pre-determine traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.1.0-2.0-1	The ASCT shall operate non-adaptively when a user-specified detector fails.	4.14-1 The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Desirable
2.1.1.0-2.0-2	The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	4.14-1 The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Highly Desirable
2.1.1.0-2.0-4	The ASCT shall operate non-adaptively when a user-defined communications link fails.	4.14-1 The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Highly Desirable
2.1.1.0-3	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	4.7-3 The system operator needs to over-ride adaptive operation.						Highly Desirable
2.1.1.0-4	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptive operation.	4.7-3 The system operator needs to over-ride adaptive operation.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.1.0-5	The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.	4.7-2 The system operator needs the ability to schedule pre-determined operation by time of day. 4.7-3 The system operator needs to over-ride adaptive operation.						Highly Desirable
2.1.1.0-7.0-1	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the signal controllers, maximizing the throughput of the coordinated route.	4.1-1 Maximize the throughput on coordinated routes 4.1-9 The system operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.						Highly Desirable
2.1.1.0-7.0-2	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.	4.1-1 Maximize the throughput on coordinated routes 4.1-9 The system operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.						Highly Desirable
2.1.1.0-7.0-3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.	4.1-3 Distribute phase times in an equitable fashion 4.1-9 The ASCT needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.1.0-7.0-4	When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.	4.1-2 Provide smooth flow along coordinated routes 4.1-9 The ASCT needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.						Highly Desirable
2.1.1.0-8	The ASCT shall provide user-specified maximum and minimum phase times.	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).						Highly Desirable
2.1.1.0-9	The ASCT shall detect repeated phases that do not serve all waiting vehicles. (These phase failures may be inferred, such as by detecting repeated max-out.)	4.1.0-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues.						Desirable
2.1.1.0-9.0-1	The ASCT shall alter operations, to minimize repeated phase failures.	4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues.						Desirable
2.1.1.0-10	The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-4 Manage the length of queues						Desirable
2.1.1.0-11	The ASCT shall provide coordination along a route.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.1.0-11.0-1	The ASCT shall coordinate along a user-defined route.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Highly Desirable
2.1.1.0-11.0-2	The ASCT shall determine the coordinated route based on traffic conditions.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Desirable
2.1.1.0-11.0-3	The ASCT shall determine the coordinated route based on a user-defined schedule.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Highly Desirable
2.1.1.0-11.0-4	The ASCT shall store a minimum of 4 user-defined coordination routes.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Desirable
2.1.1.0-11.0-4.0-1	The ASCT shall implement a stored coordinated route by operator command.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Desirable
2.1.1.0-11.0-4.0-2	The ASCT shall implement a stored coordinated route based on traffic conditions.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Desirable
2.1.1.0-11.0-4.0-3	The ASCT shall implement a stored coordinated route based on a user-defined schedule.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.1.0-11.0-5	The ASCT shall not prevent non coordinated phases from being repeated more than once in a single cycle	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.						Desirable
2.1.2	**2.1.2 Allowable Phases**							
2.1.2.0-1	The ASCT shall not prevent protected/permissive left turn phase operation.	4.9-5 Protected/permissive phasing and alternate left turn phase sequences						Highly Desirable
2.1.2.0-2	The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	4.9-5 Protected/permissive phasing and alternate left turn phase sequences						Highly Desirable
2.1.2.0-3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	5.6-6 Prevent one or more phases being skipped under certain traffic conditions or signal states						Desirable
2.1.2.0-5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	5.6-6 Prevent one or more phases being skipped under certain traffic conditions or signal states						Desirable
2.1.2.0-6	The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.	5.6-7 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.						Desirable
2.1.2.0-7	The ASCT shall omit a user-specified phase based on measured traffic conditions for 1) a current cycle, and 2) a user defined number of cycles before returning to normal adaptive operations.	5.6-7 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.						Desirable
2.1.2.0-9	The ASCT shall omit a user-specified phase according to a time of day schedule	5.6-7 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.2.0-10	The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows: · next phase; · next coordinated phase; · user-specified phase.	5.6-1 Allow the operator to specify which phase receives unused time from a preceding phase						Desirable
2.1.2.0-11	The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows: · previous phase; · next phase; · next coordinated phase; · user-specified phase.	5.6-1 Allow the operator to specify which phase receives unused time from a preceding phase						Desirable
2.1.2.0-12	The ASCT shall not alter the order of phases at a user-specified intersection.	4.1-14 The system operator needs to fix the sequence of phases at any specified location. For example, the operator may need to fix the phase order at at locations where a lagging left turn provides unsafe operations.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
2.1.2.0-13	The ASCT shall not prevent repeat phases or phase reservices	3.6.2						Desirable
2.1.2.0-14	The ASCT shall not prevent variable phase sequencing							Desirable
2.1.2.0-15	The ASCT shall not prevent detector switching							Desirable
2.1.2.0-16	The ASCT shall not prevent early release of hold phases							Desirable
2.1.2.0-17	The ASCT shall not prevent late phase introduction							Desirable
2.1.2.0-18	The ASCT shall not prevent Dynamic Max.							Desirable
2.1.2.0-19	The ASCT shall not prevent Floating Force Offs							Desirable
2.1.2.0-20	The ASCT shall not prevent offset correction transition features							Desirable
2.1.2.0-21	The ASCT shall not prevent user-selected fixing of phases sequencing at user-selected locations	The following features are currently used in coordination patterns and will need to remain available in fallback operation should the ASCT fail. See concept of operations for reference.						Desirable
2.1.2.0-22	The ASCT shall not prevent user-selected phases from being skipped under user-defined traffic conditions							Desirable
2.1.2.0-24	The ASCT shall not prevent double cycles or half cycles							Desirable
2.1.2.0-25	The ASCT shall not prevent omitting of phases							Desirable
2.1.2.0-26	The ASCT shall not prevent holding the position of uncoordinated phases							Desirable
2.1.2.0-27	The ASCT shall not prevent coordination of phases by time of day							Desirable
2.1.2.0-28	The ASCT shall not prevent coordination of turn movement phases.							Desirable
2.1.3	**2.1.3 Oversaturation**							
2.1.3.0-1	The ASCT shall detect the presence of queues at pre-configured locations.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location						Desirable

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2.1.3.0-2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location						Highly Desirable
2.1.3.0-3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location						Desirable
2.1.3.0-8	When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location						Desirable

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2.2	**2.2 Sequence-based Adaptive Coordination**							
2.2.0-2	**(Sequence-based only)** The ASCT shall select cycle length based on a time of day schedule.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Highly Desirable
2.2.0-3	**(Sequence-based only)** The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .	4.1-3 Distribute phase times in an equitable fashion 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues						Highly Desirable
2.2.0-4	**(Sequence-based only)** The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-4 Manage the length of queues						Desirable

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2.2.0-4.0-1	**(Sequence-based only)** The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-4 Manage the length of queues						Desirable
2.2.0-5	**(Sequence-based only)** The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Highly Desirable
2.2.0-5.0-3	**(Sequence-based only)** The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Desirable

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2.2.0-5.0-4	**(Sequence-based only)** The ASCT shall limit changes in cycle length to not exceed a user-specified value.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Highly Desirable
2.2.0-5.0-5	**(Sequence-based only)** The ASCT shall adjust offsets to minimize the chance of stopping vehicles approaching a signal that have been served by a user-specified phase at an upstream signal.	4.1-11 Minimize the chance that a queue forms at a specified location						Desirable
2.3	**2.3 Non-sequence-based adaptive coordination**							
2.3.0-2	**(Non-sequence-based only)** The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Desirable
2.3.0-3	**(Non-sequence-based only)** At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Desirable

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2.3.0-4	**(Non-sequence-based only)** When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues						Desirable
2.3.0-5	**(Non-sequence-based only)** The ASCT shall adjust signal timing so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	4.1-11 Minimize the chance that a queue forms at a specified location						Desirable
2.4	**2.4 Single intersection adaptive operation**							
2.4.0-2	The ASCT shall calculate a cycle length of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).						Desirable
2.4.0-3	The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).						Desirable

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2.4.0-3.0-1	The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value.	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).						Desirable
2.4.0-3.0-2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).						Desirable
2.4.0-4	The ASCT shall calculate phase order, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).						Desirable
2.6	**2.6 Responsiveness**							
2.6.0-1	The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value.	4.8-2 The system should monitor traffic and adjust in real-time to changes in traffic or queuing						Desirable
2.6.0-2	The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. (This does not apply to early gap-out or actuated phase skipping.)	4.8-2 The system should monitor traffic and adjust in real-time to changes in traffic or queuing						Desirable

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2.6.0-3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	4.8-2 The system should monitor traffic and adjust in real-time to changes in traffic or queuing 4.8-1 The responsiveness of the system shall be user programmable. The system operator needs the ability to limit the frequency of cycle changes, if necessary, and also provide limits for the minimum and maximum cycle length.						Desirable
2.6.0-5	The ASCT shall select cycle length from a list of user-defined cycle lengths.	4.8-1 The responsiveness of the system shall be user programmable. The system operator needs the ability to limit the frequency of cycle changes, if necessary, and also provide limits for the minimum and maximum cycle length.						Desirable
3	**3 External/Internal Interfaces**							
4	**4 Crossing Arterials and Boundaries**							
4.0-1.0-4	The ASCT shall support adaptive coordination on crossing routes.	5.4-1 A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.						Highly Desirable

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5	5 Access and Security							
5.0-1	The ASCT shall be implemented with a security policy that addresses the following selected elements:							
5.0-1.0-1	· Local access to the ASCT.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-2	· Remote access to the ASCT.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-3	· System monitoring.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-4	· System manual override.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable

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5.0-1.0-5	· Development	4.4-1 The system operator needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-6	· Operations	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-7	· User login	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-8	· User password	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable

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5.0-1.0-9	· Administration of the system	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-10	· Signal controller group access	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-11	· Access to classes of equipment	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable

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5.0-1.0-13	· Output activation	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-14	· System parameters	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-15	· Report generation	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-16	· Configuration	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable

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5.0-1.0-17	· Security alerts	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-18	· Security logging	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-19	· Security reporting	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-1.0-20	· Database	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable

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5.0-1.0-21	· Signal controller	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.						Highly Desirable
5.0-2	The ASCT shall provide monitoring and control access at the following locations:							
5.0-2.0-1	· City of Renton TMC	4.10-1 Agency TMC						Highly Desirable
5.0-2.0-3	· Agency LAN or WAN	4.10-2 Workstations on agency LAN or WAN at Renton City Hall						Highly Desirable
5.0-2.0-5	· Local controller cabinets	4.10-3 Local controller cabinets						Highly Desirable
5.0-2.0-7	· Through VPN into City's traffic signal system network	4.10-4 Remote locations						Highly Desirable
5.0-4	The ASCT shall not prevent access to the local signal controller database, monitoring or reporting functions by any installed signal management system.	4.10-1 The operator needs to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system from the access points defined for those system components.						Highly Desirable
6	**6 Data Log**							
6.0-1	The ASCT shall log or allow an installed signal management system to log the following events:							
6.0-1.0-1	Time-stamped vehicle phase calls	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.						Highly Desirable

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6.0-1.0-2	Time-stamped pedestrian phase calls	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.						Highly Desirable
6.0-1.0-3	Time-stamped emergency vehicle preemption calls	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.						Highly Desirable
6.0-1.0-6	Time-stamped start and end of each phase	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.						Highly Desirable
6.0-1.0-7	Time-stamped controller interval changes	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.						Highly Desirable
6.0-1.0-8	Time-stamped start and end of each transition to a new timing plan	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.						Highly Desirable

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6.0-2	The ASCT shall export its systems log in the following formats:	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.						
	· MS Excel							Highly Desirable
	· Text							Desirable
	· CSV							Highly Desirable
	· Open source SQL database							Desirable
6.0-3	The ASCT shall store the event log for a minimum of 365 days with the ability to archive data	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.						Highly Desirable
6.0-4	The ASCT shall store results of all signal timing parameter calculations for a minimum of 365 days with the ability to archive data	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format. 4.11-3 The system operator needs to store and report data that can be used to measure traffic performance under adaptive control						Desirable

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6.0-5	The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of 365 days with the ability to archive data:	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions. 4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format. 4.11-3 The system operator needs to store and report data that can be used to measure traffic performance under adaptive control						
	· volume							Desirable
	· occupancy							Desirable
	· queue length							Desirable
	· phase utilization							Desirable
	· arrivals in green							Desirable
	· green band efficiency							Desirable
6.0-6	The ASCT system shall archive all data automatically after a user-specified period not less than 365 days with the ability to archive data.	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.						Desirable
6.0-7	The ASCT shall provide data storage for a system size of 14 signal controllers. The data to be stored shall include the following:	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.						
	· Controller state data							Desirable
	· Reports							Desirable
	· Log data							Desirable
	· Security data							Desirable
	· ASCT parameters							Desirable
	· Detector status data							Desirable

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6.0-8	The ASCT shall calculate and report relative data quality including:	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						
	· The extent data is affected by detector faults							Desirable
	· Other applicable items							Desirable
6.0-9	The ASCT shall report comparisons of logged data when requested by the user:	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						
	· Day to day,							Desirable
	· Hour to hour							Desirable
	· Hour of day to hour of day							Desirable
	· Hour of week to hour of week							Desirable
	· Day of week to day week							Desirable
	· Day of year to day year							Desirable
6.0-10	The ASCT shall store data logs in a Excel and CVS format	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.						Highly Desirable
6.0-11	The ASCT shall report stored data in a form suitable to provide explanations of system behavior to public and politicians and to troubleshoot the system.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						Desirable

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6.0-12	The ASCT shall store the following data in 5 minute increments:	4.11-5						
	· volume	The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.						Desirable
	· occupancy	4.11-3						Desirable
	· queue length	The system operator needs to store and report data that can be used to measure traffic performance under adaptive control.						Desirable
7	**7 Advanced Controller Operation**							
7.0-1	When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.	4.9.1-1 Service a phase more than once per cycle						Highly Desirable
7.0-2	The ASCT shall provide a minimum of 4 phase overlaps.	4.9.1-2 Operate at least 4 overlap phases						Highly Desirable
7.0-3	The ASCT shall accommodate a minimum of 16 phases at each signal	4.9.1-3 Operate four rings, 16 phases and up to four phases per ring.						Highly Desirable
7.0-4	The ASCT shall accommodate a minimum of 4 rings at each signal.	4.9.1-3 Operate four rings, 16 phases and up to four phases per ring.						Highly Desirable
7.0-5	The ASCT shall accommodate a minimum of 4 phases per ring	4.9.1-3 Operate four rings, 16 phases and up to four phases per ring.						Highly Desirable
7.0-7	The ASCT shall not prevent a phase/overlap output by time-of-day.	4.9.1-4 The system operator needs to modify the sequence of phases to support the various operational strategies.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
7.0-11	The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn with the following characteristics:	4.9.1-8						
	· Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day	Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day						Highly Desirable
	· Ability to hold a flashing yellow arrow until a conflicting pedestrian movement clears							Highly Desirable
	· Ability to hold a flashing yellow arrow until adequate gaps in traffic are detected							Highly Desirable
	· Ability to switch to protected only operations based on volume inputs, external inputs or by time of day							Highly Desirable
7.0-12.0-1	The ASCT shall operate adaptively using user-specified detector channels to allow the controller to respond independently to individual lanes of an approach.	4.9.1-9 Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.						Desirable
7.0-13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.	4.9.1-16 Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination (e.g., double-cycle, mid-block pedestrian crossing signals)						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
7.0-14	The ASCT shall not prevent the following custom features used by the City of Renton.	4.9.2 Accommodate the following custom features used by this agency (see concept of operations)						
	· Bike Green							Desirable
	· Bike Passage							Desirable
	· Bike Detection							Desirable
	· Walk offsets							Desirable
	· Extended Pedestrian clearances							Desirable
	· Detector Switching							Desirable
	· Four+ phase banks							Desirable
8	**8 Pedestrians**							
8.0-2	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	4.6-1 The system operator needs to accommodate intermittent pedestrian operation while maintaining adaptive operation.						Highly Desirable
8.0-6	The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist:	4.9.1-11 Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination						Desirable
	· The user enables this feature							
	· Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase							
	· The phase is called after its normal start time							
	· The associated pedestrian phase is not called							
8.0-9	The ASCT shall not inhibit negative vehicle and pedestrian phase timing.	4.9.1-12 Use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
9	**9 Special Functions**							
10	**10 Detection**							
10.0-1	The ASCT shall be compatible with the following detector technologies:	4.15-1						
	Video detection	The City would prefer that the chosen ASCT system be able to use the existing loop detection since equipment is already in place at each intersection. However, the City would be open to replace the loop detection equipment with video detection equipment if an appropriate ASCT system that meets all other operational needs and requirements requires new detection equipment within a pre-determined budget.						Desirable
	Loop detection							Desirable
11	**11 Emergency Vehicle Preemption**							
11.0-2	The ASCT shall maintain adaptive operation at non-preempted intersections during emergency vehicle preemption.	8.6.1-1 When an intersection responds to emergency vehicle pre-emption, other signals within the coordinated group continue to operate adaptively.						Highly Desirable
11.0-4	The ASCT shall resume adaptive control of signal controllers when preemptions are released.	8.6.1-2 The preempted signal returns to adaptive control once the pre-emption is released.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
11.0-7	The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.	3.6.2-10 Complex coordination features that shall remain available: Emergency pre-emption and advanced pre-emption						Desirable
11.0-8	The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.	3.6.2-10 Complex coordination features shall remain available: Emergency pre-emption and advanced pre-emption						Desirable
12	**12 Transit Priority**							
12.0-1	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-2	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-2.0-1	The advance of start of green phase shall be user-defined.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-2.0-2	Adaptive operations shall continue during the advance of the start of green phase.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-3	The ASCT shall delay the end of a green phase, in response to a priority call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
12.0-3.0-1	The delay of end of green phase shall be user-defined.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-3.0-2	Adaptive operations shall continue during the delay of the end of green phase.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-4	The ASCT shall permit at least 4 exclusive transit phases.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-4.0-1	Adaptive operations shall continue when there is an exclusive transit phase call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor						Desirable
12.0-5.0-2	The ASCT shall control vehicle phases independently of Bus only phases	4.19-1 The system operator needs to accommodate emergency vehicle preemption by returning to the System Operator defined optimization strategy as efficiently as possible following a preempt.						Desirable
13	**13 Failure Events and Fallback**							
13.1	**13.1 Detector Failure**							
13.1.0-1	The ASCT shall take user-specified action in the absence of valid detector data from one or more vehicle detectors within a group.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
13.1.0-1.0-1	The ASCT shall release control to central system control.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Desirable
13.1.0-1.0-2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Highly Desirable
13.1.0-2	The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector:							
13.1.0-2.0-1	· Data from a user-specified alternate detector.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Desirable
13.1.0-2.0-2	· Stored historical data from the failed detector.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
13.1.0-2.0-3	The ASCT shall switch to the alternate source in real time without operator intervention.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.						Desirable
13.1.0-3	In the event of a detector failure, the ASCT shall issue an alarm to maintenance and operations staff.	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.						Highly Desirable
13.1.0-4	In the event of a failure, the ASCT shall log details of the failure in a permanent log.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.						Highly Desirable
13.1.0-5	The permanent failure log shall be searchable, archivable and exportable.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.						Desirable
13.2	**13.2 Communications Failure**							
13.2-1	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group.	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						Highly Desirable
13.2-1.0-1	In the event of loss of communication to a user-specified signal controller, the ASCT shall release control of all signal controllers within a user-specified group to local control.	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
13.2-1.0-2	The ASCT shall switch to the alternate operation in real time without operator intervention.	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						Highly Desirable
13.2-1.0-2.0-1	The ASCT shall revert to time-of-day operations, or	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						
13.2-1.0-2.0-2	The ASCT shall revert to free operation							Highly Desirable
13.2-2	In the event of communications failure, the ASCT shall issue an alarm to maintenance and operations staff	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.						Highly Desirable
13.2-3	The ASCT shall issue an alarm via e-mail and/or text within 5 minutes of detection of a failure.	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.						Highly Desirable
13.2-4	In the event of a communications failure, the ASCT shall log details of the failure in a permanent log.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.						Desirable
13.2-5	The permanent failure log shall be searchable, archivable and exportable.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
13.3	**13.3 Adaptive Processor Failure**							
13.3-1	The ASCT shall execute user-specified actions when adaptive control fails.	8.7.3-1 If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						Highly Desirable
13.3-1.0-1	The ASCT shall release control to central system control.	8.7.3-1 If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						Highly Desirable
13.3-1.0-2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	8.7.3-1 If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.						Highly Desirable
13.3-2	In the event of adaptive processor failure, the ASCT shall issue an alarm to maintenance and operations staff	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.						Highly Desirable
13.3-3	In the event of an adaptive processor failure, the ASCT shall log details of the failure in a permanent log. The permanent failure log shall be searchable, archivable and exportable.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.						Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
13.3-4	During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	8.7.3-2 During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.						Desirable
14	**14 Software**							
14.0-1	The vendor's adaptive software shall be fully operational within the following platform: · Windows-PC, Windows-Server	7.7-1 The system operator needs to use equipment and software acceptable under current agency IT policies and procedures with the City of Renton.						Highly Desirable
14.0-3	The ASCT shall fully satisfy all requirements without limitations when installed on M52 controllers.	6-1 The system must be compatible with M52 controllers.						Highly Desirable
14.0-3	The ASCT shall communicate with central over an Ethernet over fiber network.	7.3-1 The communications media available for use by the system will be the City of Renton's fiber/Ethernet network. The adaptive system will operate within the local ITS Architecture (Transportation network) of the City.						Highly Desirable
14.0-4	The ASCT must use the existing controller software and central system.	6-2 The system operator shall not require any modifications to the existing controller software and central system.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
15	**15 Training**							
15.0-1	The vendor shall provide the following training:							
15.0-1.0-1	The vendor shall provide training on the operations of the adaptive system.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-2	The vendor shall provide training on troubleshooting the system.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-3	The vendor shall provide training on preventive maintenance and repair of equipment.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-4	The vendor shall provide training on system configuration.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-5	The vendor shall provide training on administration of the system.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-6	The vendor shall provide training on system calibration.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-8	The vendor's training shall be delivered at the City of Renton.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
15.0-1.0-9	The vendor shall provide a minimum of 16 hours of training	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
15.0-1.0-10	The vendor shall provide 8 days of training before the system is deployed and additional 8 days of follow up training 3 months after the system has been in full operations	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.						Highly Desirable
16	**16 Maintenance, Support and Warranty**							
16.0-1	The Maintenance Vendor shall provide maintenance according to a separate maintenance contract. That contract should identify repairs necessary to preserve requirements fulfillment, responsiveness in effecting those repairs, and all requirements on the maintenance provider while performing the repairs.	4.16-2 Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment						Highly Desirable
16.0-2	The Vendor shall provide routine updates to the software and software environment necessary to preserve the fulfillment of requirements for a period not less than 5 years. Preservation of requirements fulfillment especially includes all IT management requirements as previously identified.	4.16-2 Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment						Highly Desirable
16.0-3	The Vendor shall warrant the system to be free of defects in materials and workmanship for a period of 2 years. Warranty is defined as correcting defects in materials and workmanship (subject to other language included in the purchase documents). Defect is defined as any circumstance in which the material does not perform according to its specification.	4.16-2 Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
17	**17 Schedule**							
17.0-3	The ASCT operational parameters shall be settable according to a Time of Day schedule	4.9-8 Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day 4.9-14 The ability to operate different phase sequences based on different traffic conditions or by time-of-day 4.9-16 The ability to adjust operations based on a time-of-day schedule						Desirable
18	**18 Performance Measurement, Monitoring and Reporting**							
18.0-1	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.						Desirable
18.0-2	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.						Desirable
18.0-3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions. 4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.						Highly Desirable

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Meets Requirements	Partially Meets Requirements	Requirement in Development	Requirement Not Available	Briefly discuss how requirement is met and if partially met or in development, how it could be met before the City of Renton Verification	Desirable/Highly Desirable
18.0-3.0-1	The ASCT log shall include all events directed by the external inputs.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						Desirable
18.0-3.0-2	The ASCT log shall include all external output state changes.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						Desirable
18.0-3.0-3	The ASCT log shall include all actual parameter values that are subject to user-specified values.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						Desirable
18.0-3.0-4	The ASCT shall maintain the records in this ASCT log of a minimum of 90 days.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						Desirable
18.0-3.0-5	The ASCT shall archive the ASCT log after 90 days	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.						Desirable

Appendix C: Verification Plan

1. Purpose of Document

The purpose of this document is to layout the verification plan of the adaptive signal control technology (ASCT) that will be implemented at the City of Renton. This document is part of the System Engineering documents that have been developed by the City of Renton to select and deploy an ASCT system. Completion of this testing procedure is a requirement for agencies using federal grant money to fund an ASCT project. This document describes the scope of the project; the referenced documents that are used to prepare the verification plan; details of conducting the verification; and a list of the operational needs, (defined by the "Needs Statements" in the attached table) and corresponding System Requirements to be tested.

The intended audience of this document includes the existing stakeholders for Renton's signal system:

- WSDOT
- FHWA
- City of Renton

2. Scope of Project

The scope of the project includes the implementation of ASCT at up to 13 intersections along SW 43rd Street/Carr Road/Petrovitsky Road in the City of Renton. The adaptive signal control technology will optimize traffic signal operation and reduce or eliminate some limitations of the existing signal control system.

3. Referenced Documents

The following documents supported the preparation of the verification plan:

- FHWA-HOP-11-027: "Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems," August 2012
- City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology: System Requirements, October 2015
- City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology: Concept of Operations, October 2015
- City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology: Validation Plan, October 2015

Each of the System Requirements identified by the City of Renton shall be tested according to this Verification Plan. The ASCT Vendor shall conduct the verification in the presence of City of Renton staff or its consultant. The attached verification table identifies the test location for each System Requirement. The test location is identified as "bench", "field", or both. If required, the Vendor shall conduct bench testing of the identified System Requirements at a City of Renton facility. If both bench and field testing is required, the Vendor shall conduct bench testing before the field verification tests for the identified System Requirements. Testing shall be performed on a variety of phase sequencing plans.

The Vendor shall coordinate all field tests with the City of Renton to schedule testing time periods and to gain access to hardware such as detection and controller equipment. Traffic surveillance cameras will be available for use by the Vendor during testing.

The Vendor shall use the table provided to document the test results. Any failure or lack of performance to meet the stated System Requirements shall be recorded at the time of test and the Vendor shall prepare a report stating why certain System Requirements were not met. The report shall include a proposed solution to resolve the deficiency and shall be submitted to the City within seven days of the failure. Those solutions shall not include software revisions. Upon completion of all required verification testing, the Vendor shall prepare a final verification report, which will contain all information regarding testing, including both failures and successes. This shall also include a summary of plans developed to resolve failures . The final verification report shall include a list of all hardware, software and special equipment utilized in the testing.

4. Verification Identification

The attached verification table identifies the System Requirements that shall be tested and documented by the Vendor. Each System Requirement consists of one or more "Need Statement." The number above each Need Statement references the Concept of Operations document section that describes that need. The tests do not need to be conducted in the order presented. The Vendor is allowed to rearrange the verification tests into "cases," as desired, to more efficiently test the system. A "case" is a logical grouping of functions and performance criteria that are verified together. The verification conductor shall provide the proposed logical grouping (if re-arranged) to the City for review and approval before conducting the verification tests.

Prior to testing, the Vendor and City of Renton staff shall review the verification table and proposed cases to document the following:

- Hardware and software items needed to perform the verification and a description of the setup requirements
- Data to be recorded, if any, that is specific to the output of the selected system
- A list of any other important assumptions or constraints on the testing that are specific to the selected system

City of Renton SW 43rd Street/Carr Road/Petrovitsky Road
Adaptive Signal Control Technology
Verification Plan
December 2015

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
1	**1 Network Characteristics**					
1.0-1	The ASCT shall control a minimum of 14 signals concurrently	4.2-1 The system operator needs to eventually adaptively control up to 13 signals, up to 10 miles from the TMC. Possible future expansion could increase the number of signals to 14.	Highly Desirable	Bench		
1.0-2	The ASCT shall support groups of signals.	4.2-2 The system operator needs to be able to adaptively control up to 4 independent groups of signals 4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Highly Desirable	Bench		
1.0-2.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	4.2-2 The system operator needs to be able to adaptively control up to 4 independent groups of signals	Highly Desirable	Bench		
1.0-2.0-2	The ASCT shall control a minimum of 4 groups of signals.	4.2-2 The system operator needs to be able to adaptively control up to 4 independent groups of signals	Highly Desirable	Bench		
1.0-2.0-3	The size of a group shall range from 1 to 7 signals.	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Highly Desirable	Bench		

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1.0-2.0-4	Each group shall operate independently	4.2-2 The system operator needs to be able to adaptively control up to 20 independent groups of signals	Highly Desirable	Bench		
1.0-2.0-5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the ASCT system according to configured parameters.	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Desirable	Bench		
1.0-2.0-5.0-1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to a time of day schedule. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Desirable	Bench		
1.0-2.0-5.0-2	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to traffic conditions. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Desirable	Field		
1.0-2.0-5.0-3	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.	4.2-3 The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	Desirable	Bench		
2	**2 Type of Operation**					
2.1	**2.1 General**					
2.1.1	**2.1.1 Mode of Operation**					
2.1.1.0-2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	4.7-1 The system operator needs to pre-determine traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	Highly Desirable	Bench & Field		

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2.1.1.0-2.0-1	The ASCT shall operate non-adaptively when a user-specified detector fails.	4.14-1 The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Desirable	Bench & Field		
2.1.1.0-2.0-2	The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	4.14-1 The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Highly Desirable	Bench & Field		
2.1.1.0-2.0-4	The ASCT shall operate non-adaptively when a user-defined communications link fails.	4.14-1 The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Highly Desirable	Bench & Field		
2.1.1.0-3	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	4.7-3 The system operator needs to over-ride adaptive operation.	Highly Desirable	Bench & Field		
2.1.1.0-4	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptive operation.	4.7-3 The system operator needs to over-ride adaptive operation.	Highly Desirable	Bench & Field		

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2.1.1.0-5	The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.	4.7-2 The system operator needs the ability to schedule pre-determined operation by time of day. 4.7-3 The system operator needs to over-ride adaptive operation.	Highly Desirable	Bench & Field		
2.1.1.0-7.0-1	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the signal controllers, maximizing the throughput of the coordinated route.	4.1-1 Maximize the throughput on coordinated routes 4.1-9 The system operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	Highly Desirable	Field		
2.1.1.0-7.0-2	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.	4.1-1 Maximize the throughput on coordinated routes 4.1-9 The system operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	Highly Desirable	Field		
2.1.1.0-7.0-3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.	4.1-3 Distribute phase times in an equitable fashion 4.1-9 The ASCT needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	Highly Desirable	Field		

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2.1.1.0-7.0-4	When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.	4.1-2 Provide smooth flow along coordinated routes 4.1-9 The ASCT needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	Highly Desirable	Field		
2.1.1.0-8	The ASCT shall provide user-specified maximum and minimum phase times.	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Highly Desirable	Bench		
2.1.1.0-9	The ASCT shall detect repeated phases that do not serve all waiting vehicles. (These phase failures may be inferred, such as by detecting repeated max-out.)	4.1.0-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues.	Desirable	Field		
2.1.1.0-9.0-1	The ASCT shall alter operations, to minimize repeated phase failures.	4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues.	Desirable	Field		
2.1.1.0-10	The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-4 Manage the length of queues	Desirable	Bench & Field		
2.1.1.0-11	The ASCT shall provide coordination along a route.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Highly Desirable	Field		

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2.1.1.0-11.0-1	The ASCT shall coordinate along a user-defined route.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Highly Desirable	Bench & Field		
2.1.1.0-11.0-2	The ASCT shall determine the coordinated route based on traffic conditions.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Desirable	Field		
2.1.1.0-11.0-3	The ASCT shall determine the coordinated route based on a user-defined schedule.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Highly Desirable	Bench		
2.1.1.0-11.0-4	The ASCT shall store a minimum of 4 user-defined coordination routes.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Desirable	Bench		
2.1.1.0-11.0-4.0-1	The ASCT shall implement a stored coordinated route by operator command.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Desirable	Bench & Field		
2.1.1.0-11.0-4.0-2	The ASCT shall implement a stored coordinated route based on traffic conditions.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Desirable	Field		
2.1.1.0-11.0-4.0-3	The ASCT shall implement a stored coordinated route based on a user-defined schedule.	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Desirable	Bench & Field		

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2.1.1.0-11.0-5	The ASCT shall not prevent non coordinated phases from being repeated more than once in a single cycle	4.1-14 The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	Desirable	Bench		
2.1.2	**2.1.2 Allowable Phases**					
2.1.2.0-1	The ASCT shall not prevent protected/permissive left turn phase operation.	4.9-5 Protected/permissive phasing and alternate left turn phase sequences	Highly Desirable	Bench		
2.1.2.0-2	The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	4.9-5 Protected/permissive phasing and alternate left turn phase sequences	Highly Desirable	Bench		
2.1.2.0-3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	5.6-6 Prevent one or more phases being skipped under certain traffic conditions or signal states	Desirable	Bench		
2.1.2.0-5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	5.6-6 Prevent one or more phases being skipped under certain traffic conditions or signal states	Desirable	Bench		
2.1.2.0-6	The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.	5.6-7 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	Desirable	Bench		
2.1.2.0-7	The ASCT shall omit a user-specified phase based on measured traffic conditions for 1) a current cycle, and 2) a user defined number of cycles before returning to normal adaptive operations.	5.6-7 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	Desirable	Bench		
2.1.2.0-9	The ASCT shall omit a user-specified phase according to a time of day schedule	5.6-7 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	Desirable	Bench		

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2.1.2.0-10	The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows: · next phase; · next coordinated phase; · user-specified phase.	5.6-1 Allow the operator to specify which phase receives unused time from a preceding phase	Desirable	Bench		
2.1.2.0-11	The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows: · previous phase; · next phase; · next coordinated phase; · user-specified phase.	5.6-1 Allow the operator to specify which phase receives unused time from a preceding phase	Desirable	Bench		
2.1.2.0-12	The ASCT shall not alter the order of phases at a user-specified intersection.	4.1-14 The system operator needs to fix the sequence of phases at any specified location. For example, the operator may need to fix the phase order at at locations where a lagging left turn provides unsafe operations.	Desirable	Bench		

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2.1.2.0-13	The ASCT shall not prevent repeat phases or phase reservices	3.6.2	Desirable	Bench		
2.1.2.0-14	The ASCT shall not prevent variable phase sequencing		Desirable	Bench		
2.1.2.0-15	The ASCT shall not prevent detector switching		Desirable	Bench		
2.1.2.0-16	The ASCT shall not prevent early release of hold phases		Desirable	Bench		
2.1.2.0-17	The ASCT shall not prevent late phase introduction		Desirable	Bench		
2.1.2.0-18	The ASCT shall not prevent Dynamic Max.		Desirable	Bench		
2.1.2.0-19	The ASCT shall not prevent Floating Force Offs		Desirable	Bench		
2.1.2.0-20	The ASCT shall not prevent offset correction transition features		Desirable	Bench		
2.1.2.0-21	The ASCT shall not prevent user-selected fixing of phases sequencing at user-selected locations	The following features are currently used in coordination patterns and will need to remain available in fallback operation should the ASCT fail. See concept of operations for reference.	Desirable	Bench		
2.1.2.0-22	The ASCT shall not prevent user-selected phases from being skipped under user-defined traffic conditions		Desirable	Bench		
2.1.2.0-24	The ASCT shall not prevent double cycles or half cycles		Desirable	Bench		
2.1.2.0-25	The ASCT shall not prevent omitting of phases		Desirable	Bench		
2.1.2.0-26	The ASCT shall not prevent holding the position of uncoordinated phases		Desirable	Bench		
2.1.2.0-27	The ASCT shall not prevent coordination of phases by time of day		Desirable	Bench		
2.1.2.0-28	The ASCT shall not prevent coordination of turn movement phases.		Desirable	Bench		
2.1.3	**2.1.3 Oversaturation**					
2.1.3.0-1	The ASCT shall detect the presence of queues at pre-configured locations.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location	Desirable	Bench & Field		

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2.1.3.0-2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location	Highly Desirable	Bench & Field		
2.1.3.0-3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location	Desirable	Bench & Field		
2.1.3.0-8	When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value.	4.1-4 Manage the length of queues 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues 4.1-11 Minimize the chance that a queue forms at a specified location	Desirable	Bench & Field		

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2.2	**2.2 Sequence-based Adaptive Coordination**					
2.2.0-2	**(Sequence-based only)** The ASCT shall select cycle length based on a time of day schedule.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Highly Desirable	Bench		
2.2.0-3	**(Sequence-based only)** The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .	4.1-3 Distribute phase times in an equitable fashion 4.1-5 Manage the locations of queues within the network 4.1-10 Detect repeated phase failures and control signal timing to prevent phase failures from building up queues	Highly Desirable	Bench		
2.2.0-4	**(Sequence-based only)** The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-4 Manage the length of queues	Desirable	Bench		

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2.2.0-4.0-1	**(Sequence-based only)** The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-4 Manage the length of queues	Desirable	Bench		
2.2.0-5	**(Sequence-based only)** The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Highly Desirable	Bench & Field		
2.2.0-5.0-3	**(Sequence-based only)** The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Desirable	Bench & Field		

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2.2.0-5.0-4	**(Sequence-based only)** The ASCT shall limit changes in cycle length to not exceed a user-specified value.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Highly Desirable	Bench		
2.2.0-5.0-5	**(Sequence-based only)** The ASCT shall adjust offsets to minimize the chance of stopping vehicles approaching a signal that have been served by a user-specified phase at an upstream signal.	4.1-11 Minimize the chance that a queue forms at a specified location	Desirable	Bench & Field		
2.3	**2.3 Non-sequence-based adaptive coordination**					
2.3.0-2	**(Non-sequence-based only)** The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Desirable	Field		
2.3.0-3	**(Non-sequence-based only)** At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Desirable	Bench & Field		

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2.3.0-4	**(Non-sequence-based only)** When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.1-1 Maximize the throughput on coordinated routes 4.1-2 Provide smooth flow along coordinated routes 4.1-3 Distribute phase times in an equitable fashion 4.1-4 Manage the length of queues	Desirable	Bench & Field		
2.3.0-5	**(Non-sequence-based only)** The ASCT shall adjust signal timing so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	4.1-11 Minimize the chance that a queue forms at a specified location	Desirable	Bench & Field		
2.4	**2.4 Single intersection adaptive operation**					
2.4.0-2	The ASCT shall calculate a cycle length of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Desirable	Field		
2.4.0-3	The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Desirable	Field		

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2.4.0-3.0-1	The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value.	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Desirable	Field		
2.4.0-3.0-2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.1-3 Distribute phase times in an equitable fashion 4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Desirable	Field		
2.4.0-4	The ASCT shall calculate phase order, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.1-7 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Desirable	Field		
2.6	**2.6 Responsiveness**					
2.6.0-1	The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value.	4.8-2 The system should monitor traffic and adjust in real-time to changes in traffic or queuing	Desirable	Bench		
2.6.0-2	The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. (This does not apply to early gap-out or actuated phase skipping.)	4.8-2 The system should monitor traffic and adjust in real-time to changes in traffic or queuing	Desirable	Bench		

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2.6.0-3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	4.8-2 The system should monitor traffic and adjust in real-time to changes in traffic or queuing 4.8-1 The responsiveness of the system shall be user programmable. The system operator needs the ability to limit the frequency of cycle changes, if necessary, and also provide limits for the minimum and maximum cycle length.	Desirable	Bench		
2.6.0-5	The ASCT shall select cycle length from a list of user-defined cycle lengths.	4.8-1 The responsiveness of the system shall be user programmable. The system operator needs the ability to limit the frequency of cycle changes, if necessary, and also provide limits for the minimum and maximum cycle length.	Desirable	Bench		
3	**3 External/Internal Interfaces**					
4	**4 Crossing Arterials and Boundaries**					
4.0-1.0-4	The ASCT shall support adaptive coordination on crossing routes.	5.4-1 A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.	Highly Desirable	Field		

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5	5 Access and Security					
5.0-1	The ASCT shall be implemented with a security policy that addresses the following selected elements:					
5.0-1.0-1	· Local access to the ASCT.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-2	· Remote access to the ASCT.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-3	· System monitoring.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-4	· System manual override.	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		

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5.0-1.0-5	· Development	4.4-1 The system operator needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-6	· Operations	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-7	· User login	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-8	· User password	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		

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5.0-1.0-9	· Administration of the system	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-10	· Signal controller group access	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-11	· Access to classes of equipment	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		

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5.0-1.0-13	· Output activation	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-14	· System parameters	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-15	· Report generation	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-16	· Configuration	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		

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5.0-1.0-17	· Security alerts	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-18	· Security logging	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-19	· Security reporting	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-1.0-20	· Database	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		

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5.0-1.0-21	· Signal controller	4.4-1 The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	Highly Desirable	Bench		
5.0-2	The ASCT shall provide monitoring and control access at the following locations:					
5.0-2.0-1	· City of Renton TMC	4.10-1 Agency TMC	Highly Desirable	Bench		
5.0-2.0-3	· Agency LAN or WAN	4.10-2 Workstations on agency LAN or WAN at Renton City Hall	Highly Desirable	Bench		
5.0-2.0-5	· Local controller cabinets	4.10-3 Local controller cabinets	Highly Desirable	Field		
5.0-2.0-7	· Through VPN into City's traffic signal system network	4.10-4 Remote locations	Highly Desirable	Field		
5.0-4	The ASCT shall not prevent access to the local signal controller database, monitoring or reporting functions by any installed signal management system.	4.10-1 The operator needs to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system from the access points defined for those system components.	Highly Desirable	Bench		
6	**6 Data Log**					
6.0-1	The ASCT shall log or allow an installed signal management system to log the following events:					
6.0-1.0-1	Time-stamped vehicle phase calls	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	Highly Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
6.0-1.0-2	Time-stamped pedestrian phase calls	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	Highly Desirable	Bench		
6.0-1.0-3	Time-stamped emergency vehicle preemption calls	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	Highly Desirable	Bench		
6.0-1.0-6	Time-stamped start and end of each phase	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	Highly Desirable	Bench		
6.0-1.0-7	Time-stamped controller interval changes	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	Highly Desirable	Bench		
6.0-1.0-8	Time-stamped start and end of each transition to a new timing plan	4.11-1 The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	Highly Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
6.0-2	The ASCT shall export its systems log in the following formats:	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.				
	· MS Excel		Highly Desirable	Bench		
	· Text		Desirable	Bench		
	· CSV		Highly Desirable	Bench		
	· Open source SQL database		Desirable	Bench		
6.0-3	The ASCT shall store the event log for a minimum of 365 days with the ability to archive data	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.	Highly Desirable	Bench		
6.0-4	The ASCT shall store results of all signal timing parameter calculations for a minimum of 365 days with the ability to archive data	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format. 4.11-3 The system operator needs to store and report data that can be used to measure traffic performance under adaptive control	Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
6.0-5	The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of 365 days with the ability to archive data:	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions. 4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format. 4.11-3 The system operator needs to store and report data that can be used to measure traffic performance under adaptive control				
	· volume		Desirable	Bench		
	· occupancy		Desirable	Bench		
	· queue length		Desirable	Bench		
	· phase utilization		Desirable	Bench		
	· arrivals in green		Desirable	Bench		
	· green band efficiency		Desirable	Bench		
6.0-6	The ASCT system shall archive all data automatically after a user-specified period not less than 365 days with the ability to archive data.	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.	Desirable	Bench		
6.0-7	The ASCT shall provide data storage for a system size of 14 signal controllers. The data to be stored shall include the following:	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.				
	· Controller state data		Desirable	Bench		
	· Reports		Desirable	Bench		
	· Log data		Desirable	Bench		
	· Security data		Desirable	Bench		
	· ASCT parameters		Desirable	Bench		
	· Detector status data		Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
6.0-8	The ASCT shall calculate and report relative data quality including:	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.				
	· The extent data is affected by detector faults		Desirable	Bench		
	· Other applicable items		Desirable	Bench		
6.0-9	The ASCT shall report comparisons of logged data when requested by the user:	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.				
	· Day to day,		Desirable	Bench		
	· Hour to hour		Desirable	Bench		
	· Hour of day to hour of day		Desirable	Bench		
	· Hour of week to hour of week		Desirable	Bench		
	· Day of week to day week		Desirable	Bench		
	· Day of year to day year		Desirable	Bench		
6.0-10	The ASCT shall store data logs in a Excel and CVS format	4.11-2 The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.	Highly Desirable	Bench		
6.0-11	The ASCT shall report stored data in a form suitable to provide explanations of system behavior to public and politicians and to troubleshoot the system.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
6.0-12	The ASCT shall store the following data in 5 minute increments:	4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.				
	· volume		Desirable	Bench		
	· occupancy	4.11-3 The system operator needs to store and report data that can be used to measure traffic performance under adaptive control.	Desirable	Bench		
	· queue length		Desirable	Bench		
7	**7 Advanced Controller Operation**					
7.0-1	When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.	4.9.1-1 Service a phase more than once per cycle	Highly Desirable	Bench		
7.0-2	The ASCT shall provide a minimum of 4 phase overlaps.	4.9.1-2 Operate at least 4 overlap phases	Highly Desirable	Bench		
7.0-3	The ASCT shall accommodate a minimum of 16 phases at each signal	4.9.1-3 Operate four rings, 16 phases and up to four phases per ring.	Highly Desirable	Bench		
7.0-4	The ASCT shall accommodate a minimum of 4 rings at each signal.	4.9.1-3 Operate four rings, 16 phases and up to four phases per ring.	Highly Desirable	Bench		
7.0-5	The ASCT shall accommodate a minimum of 4 phases per ring	4.9.1-3 Operate four rings, 16 phases and up to four phases per ring.	Highly Desirable	Bench		
7.0-7	The ASCT shall not prevent a phase/overlap output by time-of-day.	4.9.1-4 The system operator needs to modify the sequence of phases to support the various operational strategies.	Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
7.0-11	The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn with the following characteristics:	4.9.1-8 Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day				
	· Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day		Highly Desirable	Bench		
	· Ability to hold a flashing yellow arrow until a conflicting pedestrian movement clears		Highly Desirable	Bench		
	· Ability to hold a flashing yellow arrow until adequate gaps in traffic are detected		Highly Desirable	Bench		
	· Ability to switch to protected only operations based on volume inputs, external inputs or by time of day		Highly Desirable	Bench		
7.0-12.0-1	The ASCT shall operate adaptively using user-specified detector channels to allow the controller to respond independently to individual lanes of an approach.	4.9.1-9 Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.	Desirable	Bench		
7.0-13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.	4.9.1-16 Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination (e.g., double-cycle, mid-block pedestrian crossing signals)	Desirable	Bench		

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7.0-14	The ASCT shall not prevent the following custom features used by the City of Renton.	4.9.2				
	· Bike Green	Accommodate the following custom features used by this agency (see concept of operations)	Desirable	Bench		
	· Bike Passage		Desirable	Bench		
	· Bike Detection		Desirable	Bench		
	· Walk offsets		Desirable	Bench		
	· Extended Pedestrian clearances		Desirable	Bench		
	· Detector Switching		Desirable	Bench		
	· Four+ phase banks		Desirable	Bench		
8	**8 Pedestrians**					
8.0-2	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	4.6-1 The system operator needs to accommodate intermittent pedestrian operation while maintaining adaptive operation.	Highly Desirable	Field		
8.0-6	The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist:	4.9.1-11 Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination	Desirable	Bench & Field		
	· The user enables this feature					
	· Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase					
	· The phase is called after its normal start time					
	· The associated pedestrian phase is not called					
8.0-9	The ASCT shall not inhibit negative vehicle and pedestrian phase timing.	4.9.1-12 Use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk	Highly Desirable	Bench		

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9	**9 Special Functions**					
10	**10 Detection**					
10.0-1	The ASCT shall be compatible with the following detector technologies:	4.15-1				
	Video detection	The City would prefer that the chosen ASCT system be able to use the existing loop detection since equipment is already in place at each intersection. However, the City would be open to replace the loop detection equipment with video detection equipment if an appropriate ASCT system that meets all other operational needs and requirements requires new detection equipment within a pre-determined budget.	Desirable	Bench & Field		
	Loop detection		Desirable	Bench & Field		
11	**11 Emergency Vehicle Preemption**					
11.0-2	The ASCT shall maintain adaptive operation at non-preempted intersections during emergency vehicle preemption.	8.6.1-1 When an intersection responds to emergency vehicle pre-emption, other signals within the coordinated group continue to operate adaptively.	Highly Desirable	Field		
11.0-4	The ASCT shall resume adaptive control of signal controllers when preemptions are released.	8.6.1-2 The preempted signal returns to adaptive control once the pre-emption is released.	Highly Desirable	FIeld		

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11.0-7	The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.	3.6.2-10 Complex coordination features that shall remain available: Emergency pre-emption and advanced pre-emption	Desirable	Field		
11.0-8	The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.	3.6.2-10 Complex coordination features shall remain available: Emergency pre-emption and advanced pre-emption	Desirable	Field		
12	**12 Transit Priority**					
12.0-1	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-2	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-2.0-1	The advance of start of green phase shall be user-defined.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-2.0-2	Adaptive operations shall continue during the advance of the start of green phase.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-3	The ASCT shall delay the end of a green phase, in response to a priority call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		

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12.0-3.0-1	The delay of end of green phase shall be user-defined.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-3.0-2	Adaptive operations shall continue during the delay of the end of green phase.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-4	The ASCT shall permit at least 4 exclusive transit phases.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-4.0-1	Adaptive operations shall continue when there is an exclusive transit phase call.	4.19-1 The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	Desirable	Bench		
12.0-5.0-2	The ASCT shall control vehicle phases independently of Bus only phases	4.19-1 The system operator needs to accommodate emergency vehicle preemption by returning to the System Operator defined optimization strategy as efficiently as possible following a preempt.	Desirable	Bench		
13	**13 Failure Events and Fallback**					
13.1	**13.1 Detector Failure**					
13.1.0-1	The ASCT shall take user-specified action in the absence of valid detector data from one or more vehicle detectors within a group.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Highly Desirable	Field		

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13.1.0-1.0-1	The ASCT shall release control to central system control.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Desirable	Bench & Field		
13.1.0-1.0-2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Highly Desirable	Bench & Field		
13.1.0-2	The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector:					
13.1.0-2.0-1	· Data from a user-specified alternate detector.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Desirable	Bench & Field		
13.1.0-2.0-2	· Stored historical data from the failed detector.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Desirable	Bench & Field		

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13.1.0-2.0-3	The ASCT shall switch to the alternate source in real time without operator intervention.	4.7-4 The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	Desirable	Bench & Field		
13.1.0-3	In the event of a detector failure, the ASCT shall issue an alarm to maintenance and operations staff.	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.	Highly Desirable	Bench & Field		
13.1.0-4	In the event of a failure, the ASCT shall log details of the failure in a permanent log.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.	Highly Desirable	Bench & Field		
13.1.0-5	The permanent failure log shall be searchable, archivable and exportable.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.	Desirable	Bench		
13.2	**13.2 Communications Failure**					
13.2-1	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group.	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Bench & Field		
13.2-1.0-1	In the event of loss of communication to a user-specified signal controller, the ASCT shall release control of all signal controllers within a user-specified group to local control.	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Bench & Field		

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13.2-1.0-2	The ASCT shall switch to the alternate operation in real time without operator intervention.	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Field		
13.2-1.0-2.0-1	The ASCT shall revert to time-of-day operations, or	8.7.1-1 If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Field		
13.2-1.0-2.0-2	The ASCT shall revert to free operation					
13.2-2	In the event of communications failure, the ASCT shall issue an alarm to maintenance and operations staff	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.	Highly Desirable	Bench		
13.2-3	The ASCT shall issue an alarm via e-mail and/or text within 5 minutes of detection of a failure.	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.	Highly Desirable	Bench		
13.2-4	In the event of a communications failure, the ASCT shall log details of the failure in a permanent log.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.	Desirable	Bench & Field		
13.2-5	The permanent failure log shall be searchable, archivable and exportable.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.	Desirable	Bench		

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13.3	**13.3 Adaptive Processor Failure**					
13.3-1	The ASCT shall execute user-specified actions when adaptive control fails.	8.7.3-1 If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Bench & Field		
13.3-1.0-1	The ASCT shall release control to central system control.	8.7.3-1 If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Field		
13.3-1.0-2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	8.7.3-1 If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	Highly Desirable	Field		
13.3-2	In the event of adaptive processor failure, the ASCT shall issue an alarm to maintenance and operations staff	8.7.4-1 All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.	Highly Desirable	Field		
13.3-3	In the event of an adaptive processor failure, the ASCT shall log details of the failure in a permanent log. The permanent failure log shall be searchable, archivable and exportable.	8.7.4-2 The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.	Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
13.3-4	During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	8.7.3-2 During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	Desirable	Field		
14	**14 Software**					
14.0-1	The vendor's adaptive software shall be fully operational within the following platform: · Windows-PC, Windows-Server	7.7-1 The system operator needs to use equipment and software acceptable under current agency IT policies and procedures with the City of Renton.	Highly Desirable	Bench		
14.0-3	The ASCT shall fully satisfy all requirements without limitations when installed on M52 controllers.	6-1 The system must be compatible with M52 controllers.	Highly Desirable	Bench & Field		
14.0-3	The ASCT shall communicate with central over an Ethernet over fiber network.	7.3-1 The communications media available for use by the system will be the City of Renton's fiber/Ethernet network. The adaptive system will operate within the local ITS Architecture (Transportation network) of the City.	Highly Desirable	Bench & Field		
14.0-4	The ASCT must use the existing controller software and central system.	6-2 The system operator shall not require any modifications to the existing controller software and central system.	Highly Desirable	Bench & Field		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
15	**15 Training**					
15.0-1	The vendor shall provide the following training:					
15.0-1.0-1	The vendor shall provide training on the operations of the adaptive system.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-2	The vendor shall provide training on troubleshooting the system.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-3	The vendor shall provide training on preventive maintenance and repair of equipment.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-4	The vendor shall provide training on system configuration.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-5	The vendor shall provide training on administration of the system.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-6	The vendor shall provide training on system calibration.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-8	The vendor's training shall be delivered at the City of Renton.	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
15.0-1.0-9	The vendor shall provide a minimum of 16 hours of training	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
15.0-1.0-10	The vendor shall provide 8 days of training before the system is deployed and additional 8 days of follow up training 3 months after the system has been in full operations	4.16-1 The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	Highly Desirable	N/A		
16	**16 Maintenance, Support and Warranty**					
16.0-1	The Maintenance Vendor shall provide maintenance according to a separate maintenance contract. That contract should identify repairs necessary to preserve requirements fulfillment, responsiveness in effecting those repairs, and all requirements on the maintenance provider while performing the repairs.	4.16-2 Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment	Highly Desirable	N/A		
16.0-2	The Vendor shall provide routine updates to the software and software environment necessary to preserve the fulfillment of requirements for a period not less than 5 years. Preservation of requirements fulfillment especially includes all IT management requirements as previously identified.	4.16-2 Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment	Highly Desirable	N/A		
16.0-3	The Vendor shall warrant the system to be free of defects in materials and workmanship for a period of 2 years. Warranty is defined as correcting defects in materials and workmanship (subject to other language included in the purchase documents). Defect is defined as any circumstance in which the material does not perform according to its specification.	4.16-2 Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment	Highly Desirable	N/A		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
17	**17 Schedule**					
17.0-3	The ASCT operational parameters shall be settable according to a Time of Day schedule	4.9-8 Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day 4.9-14 The ability to operate different phase sequences based on different traffic conditions or by time-of-day 4.9-16 The ability to adjust operations based on a time-of-day schedule	Desirable	Bench		
18	**18 Performance Measurement, Monitoring and Reporting**					
18.0-1	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Desirable	Bench		
18.0-2	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Desirable	Bench		
18.0-3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions. 4.11-5 The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.	Highly Desirable	Bench		

System Requirement Reference No.	ASCT System Requirement	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Desirable/Highly Desirable	Test Location	Pass/Fail	Briefly discuss the reasons if the verification test fails and how the issues will be resolved
18.0-3.0-1	The ASCT log shall include all events directed by the external inputs.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	Desirable	Bench		
18.0-3.0-2	The ASCT log shall include all external output state changes.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	Desirable	Bench		
18.0-3.0-3	The ASCT log shall include all actual parameter values that are subject to user-specified values.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	Desirable	Bench		
18.0-3.0-4	The ASCT shall maintain the records in this ASCT log of a minimum of 90 days.	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	Desirable	Bench		
18.0-3.0-5	The ASCT shall archive the ASCT log after 90 days	4.11-4 Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	Desirable	Bench		

Appendix D: Validation Plan

1. Purpose of Document

The purpose of this document is to layout the validation plan of the adaptive signal control technology (ASCT) that will be implemented at the City of Renton. This document is part of the System Engineering documents that have been developed by the City of Renton to select and deploy an ASCT system for the City. Completion of this testing procedure is a requirement for agencies using federal grant money to fund an ASCT project. This document describes the scope of the project; the referenced documents that are used to prepare the validation plan; details of conducting validation; and provides a list of the "Operational Needs" that shall be validated.

The intended audience of this document includes the existing stakeholders of City of Renton signal system:

- WSDOT
- FHWA
- City of Renton

2. Scope of Project

The scope of the project includes the implementation of ASCT at up to 13 intersections along SW 43rd Street/Carr Road/Petrovitsky Road in the City of Renton. The adaptive signal control technology will optimize traffic signal operation and reduce or eliminate some limitations of the existing signal control system.

3. Referenced Documents

The following documents supported preparation of this validation plan:

- FHWA-HOP-11-027: "Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems," August 2012
- City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology: System Requirements, October 2015
- City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology: Concept of Operations, October 2015
- City of Renton SW 43rd Street/Carr Road/Petrovitsky Road Adaptive Signal Control Technology: Verification Plan, October 2015

4. Conducting Validation

The Validation Test will be performed after the implementation of the selected adaptive signal control technology. City of Renton staff or its consultant will conduct the system validation. The person conducting the test will be referred to as the "validation conductor" in this document. The validation conductor will record the results, and prepare a summary report of the results.

Before conducting any validation tests, the validation conductor will prepare a validation procedure for the validation test. The validation procedure will describe the equipment setup, responsible personnel and steps to be followed to conduct the validation test that are specific to the system selected by the City of Renton.

The validation tests will be conducted after the system deployment and verification tests are complete. The validation conductor will configure the system software to collect and process data for validation tests. The validation conductor may need to observe traffic operation in the field or via traffic cameras to measure test outcomes of some validation tests.

Validation of some tests will require a comparison of operations before and after implementation of the ASCT system. Data to be used for validation should be collected prior to implementation of the ASCT or during a brief period after implementation when the system is turned off, specifically for collecting before data.

5. Validation Identification

The following table identifies the validation tests that will be tested and documented by the validation conductor. The validation tests will validate user needs described in the Concept of Operations document. The first two numbers of the "Validation Number" corresponds to the section of the Concept of Operation that describes the "Needs Statement."

The "Data Source" identified for each test is an estimation of the means for collecting the data needed to complete the test. The final source will be customized to match data available with the selected system. User needs related to system interface and control features will be tested through the system verification only (per "System Verification").

City of Renton SW 43rd Street/Carr Road/Petrovitsky Road
Adaptive Signal Control Technology
Validation Plan
December 2015

Validation Reference No.	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Data Source	Pass/Fail
4.1-1	Maximize the throughput on coordinated routes	Counts from Detection at Signals	
4.1-2	Provide smooth flow along coordinated routes	Signal Timing and Detector Data; Percent Arrival on Green; Field Observations	
4.1-3	Distribute phase times in an equitable fashion	Signal Timing and Detector Data; Percent Occupancy; Field Observations	
4.1-4	Manage the length of queues	Field Observations; Detector Data	
4.1-5	Manage the locations of queues within the network	Field Observations; Detector Data	
4.1-7	At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).	Signal Timing and Detector Data; Field Observations	
4.1-9	The system operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	System Inspection; Field Observations	
4.1-10	Detect repeated phase failures and control signal timing to prevent phase failures from building up queues.	System Inspection; Detector Data; Signal Timing Data	
4.1-11	Minimize the chance that a queue forms at a specified location	Field Observations; Detector Data	
4.1-14	The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	System Verification	
4.2-1	The system operator needs to eventually adaptively control up to 13 signals, up to 10 miles from the TMC. Possible future expansion could increase the number of signals to 14.	System Verification	
4.2-2	The system operator needs to be able to adaptively control up to 4 independent groups of signals	System Verification	
4.2-3	The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.	System Inspection; Field Observations	

Validation Reference No.	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Data Source	Pass/Fail
4.4-1	The system needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the agency's access and network infrastructure security policies.	System Verification	
4.6-1	The system operator needs to accommodate intermittent pedestrian operation while maintaining adaptive operation.	Signal Timing Data	
4.7-1	The system operator needs to pre-determine traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	System Inspection; Field Observations	
4.7-2	The system operator needs the ability to schedule pre-determined operation by time of day.	System Verification	
4.7-3	The system operator needs to over-ride adaptive operation.	System Verification	
4.7-4	The system operator needs to fall back to TOD or isolated free operation, as specified by the user, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	System Inspection; Field Observations	
4.8-1	The responsiveness of the system shall be user programmable. The system operator needs the ability to limit the frequency of cycle changes, if necessary, and also provide limits for the minimum and maximum cycle length.	System Verification	
4.8-2	The system should monitor traffic and adjust in real-time to changes in traffic or queuing	System Inspection; Field Observations	
4.9.2	Accommodate custom features used by this agency (see concept of operations and verification plan)	System Verification	
4.9-5	Protected/permissive phasing and alternate left turn phase sequences	System Verification	
4.9-8	Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day	System Verification	

Validation Reference No.	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Data Source	Pass/Fail
4.9-14	The ability to operate different phase sequences based on different traffic conditions or by time-of-day	System Verification	
4.9-16	The ability to adjust operations based on a time-of-day schedule	System Verification	
4.9.1-1	Service a phase more than once per cycle	System Verification	
4.9.1-2	Operate at least 4 overlap phases	System Verification	
4.9.1-3	Operate four rings, 16 phases and up to four phases per ring.	System Verification	
4.9.1-4	The system operator needs to modify the sequence of phases to support the various operational strategies.	System Verification	
4.9.1-8	Support flashing yellow arrow to control protected/permissive, protected only and permissive left turns and right turns based on external inputs or by time of day	System Verification	
4.9.1-9	Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.	System Verification	
4.9.1-11	Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination	System Verification	
4.9.1-12	Use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk	System Verification	
4.9.1-16	Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination (e.g., double-cycle, mid-block pedestrian crossing signals)	System Verification	
4.11-1	The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	System Verification	

Validation Reference No.	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Data Source	Pass/Fail
4.11-2	The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data in Excel or CSV format.	System Verification	
4.11-3	The system operator needs to store and report data that can be used to measure traffic performance under adaptive control	System Verification	
4.11-4	Have the ability to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	System Verification	
4.11-5	The system operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.	System Verification	
4.14-1	The system operator needs to fall back to TOD or isolated free operation, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure.	System Verification; signal timing data; controller log; field observation	
4.15-1	The City would prefer that the chosen ASCT system be able to use the existing loop detection since equipment is already in place at each intersection. However, the City would be open to replace the loop detection equipment with video detection equipment if an appropriate ASCT system that meets all other operational needs and requirements requires new detection equipment within a pre-determined budget.	System Verification	
4.16-1	The City of Renton needs all staff involved in operation and maintenance to receive appropriate training.	System Verification	

Validation Reference No.	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Data Source	Pass/Fail
4.16-2	Maintenance of detection equipment required for adaptive operations will be performed by City of Renton signal maintenance staff. Vendor will supply support for training and operation at the time of system deployment and for a pre-determined period following deployment	System Verification	
4.19-1	The system operator needs to accommodate bus transit signal priority while maintaining adaptive operations at an intersection or on a corridor	System Verification	
5.4-1	A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads.	System Verification	
5.6-1	Allow the operator to specify which phase receives unused time from a preceding phase	System Verification	
5.6-6	Prevent one or more phases being skipped under certain traffic conditions or signal states	System Verification	
5.6-7	Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	System Verification	
6-1	The system must be compatible with M52 controllers.	System Verification	
6-2	The system operator shall not require any modifications to the existing controller software and central system.	System Verification	
7.3-1	The communications media available for use by the system will be the City of Renton's fiber/Ethernet network. The adaptive system will operate within the local ITS Architecture (Transportation network) of the City.	System Verification	
7.7-1	The system operator needs to use equipment and software acceptable under current agency IT policies and procedures with the City of Renton.	System Verification	
8.6.1-1	When an intersection responds to emergency vehicle pre-emption, other signals within the coordinated group continue to operate adaptively.	System Inspection; Field Observations	
8.6.1-2	The preempted signal returns to adaptive control once the pre-emption is released.	System Inspection; Field Observations	

Validation Reference No.	Need Statement (#.#-# Represents Relevant Concept of Operations Section)	Data Source	Pass/Fail
8.7.1-1	If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	System Verification; signal timing data; controller log; field observation	
8.7.3-1	If a processor failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals affected or within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation.	System Verification; signal timing data; controller log; field observation	
8.7.3-2	During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	System Verification; signal timing data; controller log; field observation	
8.7.4-1	All communication, detection, and software failures will be automatically transmitted to maintenance and operations staff as an alert for appropriate attention.	System Verification; signal timing data; controller log; field observation	
8.7.4-2	The system will record a complete log of alarms and alerts that is viewable by maintenance and operations staff.	System Verification; signal timing data; controller log; field observation	