REQUEST FOR PROPOSAL (RFP)

Automated Traffic Signal Performance Management (ATSPM) SYSTEM

City of San Rafael Public Works Department
111 Morphew St, San Rafael, CA 94901
August 19, 2019

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1 INTRODUCTION

The City of San Rafael (City) strives to improve arterial operations and enhance safety at signalized intersections throughout the City starting with the Central San Rafael area by deploying an Automated Traffic Signal Performance Measures (ATSPM) system. Through the Innovative Deployments to Enhance Arterials (IDEA) Program, the Metropolitan Transportation Commission (MTC) has awarded the City with grant funding for the deployment of an ATSPM system throughout its Central San Rafael area. Federal funds available through the IDEA Program are designed to assist agencies with project implementation through capital support and technical assistance.

The core goals of this project include: improving travel time and travel reliability along arterials for autos and transit vehicles; improve safety of motorists, transit riders, bicyclists, and pedestrians and decrease motor vehicle emissions and fuel consumption. An ATSPM system will provide information/tools needed to actively monitor signal performance and proactively identify and correct deficiencies before they negatively impact arterial operations. Deploying an ATSPM system is a cost-effective way to improve traditional retiming processes by providing continuous performance monitoring capability using high-resolution data and real-time performance measures.

The RFP is a result of a year-long concerted effort by a team of professionals from MTC, DKS Associates, Advanced Mobility Group and the City of San Rafael. The team collectively produced the attached Concept of Operations, System Requirements, and Verification Plan documents.

The City hereby requests proposals from qualified firms to provide and implement an ATSPM system. Proposals shall be submitted by firms that have a capable and demonstrable background in the type of work described in Section 4, Scope of Services, of this RFP. In addition, all interested firms shall have sufficient, readily available resources in the form of trained personnel, support services, specialized staff and financial resources to carry out the work without delay or shortcomings.

1.1 City Contact

Prospective proposers may contact Lauren Davini, Traffic Engineer, for further information regarding this Request for Proposal (RFP). Deadline for inquiries is 4:00 p.m. on Thursday, August 29, 2019. Inquires will be responded no later than Friday, September 6, 2019. All requests for interpretation or questions must be sent by email and must clearly include the subject line “RFP: Inquiries for ATSPM System”.

Inquiries and written correspondence may be directed to:

Lauren Davini, Traffic Engineer
111 Morphew Street
San Rafael, CA 94901
Phone: 415-485-3361
Email: lauren.davini@cityofsanrafael.org

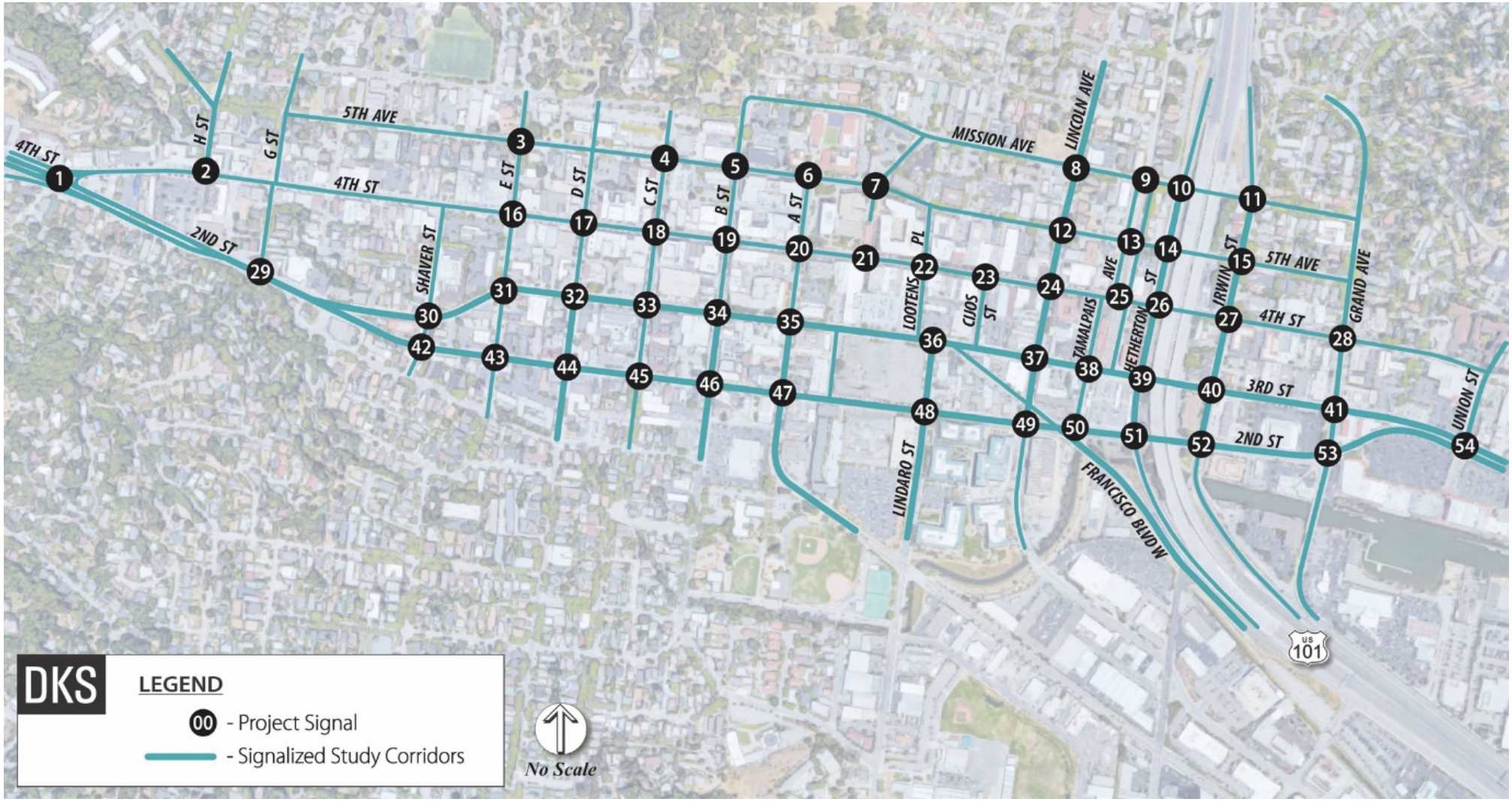
1.2 Project Description

The City is seeking to procure a commercially-available, off-the-shelf ATSPM system. Configuration of up to 54 signalized intersections within the City's downtown area (see Figure 1) will allow the City to collect high-resolution data and proactively manage the traffic signal network. The final intersection count may be adjusted to fit within the project budget given significant gaps in the communications, signal hardware and vehicle and pedestrian detection infrastructure.

Any traffic signal connected to the ATSPM system will need to allow for the collection of high-resolution data. The City is actively working to upgrade traffic signal controllers in the project area and connect them to the Econolite Centracs central traffic management system via high speed communications. Should a traffic signal not be connected to Centracs, a phased deployment of the ATSPM system may be necessary – targeted initially to those intersections with upgraded controllers and existing connections to the Centracs central system. The submittal should include cost proposals for deploying an ATSPM system at the 54 intersections as shown in Figure 1 and included in Appendix A – Concept of Operations.

The proposed ATSPM system should meet the full set of system requirements as included in Appendix B – System Requirements. The cost proposal should provide the annual cost per intersection during the first three and ten years of service contract. This would enable the City to decide on the proposed short-term (3-years) and long-term (10-years) solutions and its associated cost. Additional details regarding the goals of the system, operations, and infrastructure can be found in the Final Concept of Operations document attached to this RFP as Appendix A.

FIGURE 1: SYSTEM PROJECT LIMITS (54 INTERSECTIONS)



2 PROPOSAL REQUIREMENTS

2.1 Submittal of Proposal

Sealed proposals will be received by the City of San Rafael Public Work's office until:

4:00 pm on September 16, 2019

Proposals must be received by the time specified at the address below. Any proposals received after the deadline will not be considered. Proposals shall be clearly labeled as:

City of San Rafael Request for Proposal (RFP) – ATSPM System

Five (5) hard copies and one (1) electronic PDF copy (on a flash drive) of the proposal package must be submitted in a sealed envelope or package, delivered to:

City of San Rafael
Department of Public Works
111 Morphew Street
San Rafael, CA 94901
Attn: Lauren Davini

2.2 Proposal Submission Requirements

The proposal shall not exceed 30 pages (30 pages printed single-sided, or 15-pages printed double-sided). Excluded from the page count are: covers, dividers, table of content, resumes of the proposed staff (in an appendix), response to the Systems Requirements, the Cost Proposal, and sample maintenance agreement (in an appendix).

2.2.1 Title Page

Include a title page indicating the RFP subject, official name of the firm, mailing address, telephone number, date, name of primary contact person, and contact person's phone number and email address.

2.2.2 Transmittal Letter

The letter must be signed by an official authorized to solicit business and enter into contracts for the firm. Provide contact name with phone number and email if different from the person signing the letter. Indicate whether there are any conflicts of interest that would limit the firm's ability to provide the requested services. Acknowledge the receipt of this RFP and any addenda to the RFP. Indicate that the proposal is a firm offer to enter into a contract for a period of 120 days from the proposal due date. The letter must state that the sample Professional Services Agreement is acceptable as-is.

2.2.3 Project Understanding and Approach

This section should detail the Proposer's understanding of the project and the general approach to be taken. This section may include a discussion of known constraints, challenges, and the Proposer's

approach, solutions, and assumptions. The Proposer should describe how it would accomplish the goals and requirements of this proposal.

The project approach shall include a description of all infrastructure improvements/upgrades that would be needed at each intersection to support the proposed ATSPM system. The existing infrastructure inventory for each traffic signal is included in Appendix D – Infrastructure Inventory. If infrastructure improvements/upgrades are required at the intersections to support the proposed ATSPM system, it would be done through a separate procurement.

2.2.4 Work Plan

This section should present a work plan for the tasks described in Section 4, Scope of Services. Discuss how the Proposer will perform the identified tasks and identify deliverables. The proposal should discuss the tasks in sufficient detail to demonstrate a clear understanding of the project and component tasks. The proposal may include an alternate approach and/or additional tasks or subtasks that the Proposer believes necessary to accomplish the project.

2.2.5 Project Schedule

Include a proposed schedule for completing the work with the assumption that the infrastructure improvements/upgrades included in your approach is in place. Include/highlight major deliverables and milestones.

2.2.6 Proposed Personnel

Provide a project organization chart that shows roles and responsibilities of proposed personnel and reporting structure. Identify any sub-vendors and their role(s) and responsibilities. Resumes for proposed staff that show their relevant experience, and workplace location should be provided in an appendix.

2.2.7 Firm Qualifications

Provide a statement of qualifications and experience that uniquely qualify the Proposer to provide the services required for the completion of this project. Describe the firms on the team (including any sub-vendors) including location of offices and headquarters, number of employees, and number of years in business. Describe where the firms on the team have worked together before, if applicable. Provide a list of similar work (three projects minimum) to include dollar amount, project description, project team, and owner/client/reference contacts including phone numbers and addresses.

2.2.8 Requirements

This RFP and the related attachments contain systems requirements for the ATSPM system. The Proposer is required to respond to every requirement as included in Appendix B – Systems Requirements. For each requirement, the Proposer shall indicate if it is currently “Met”, “Partially Met”, or “Not Met” by the proposed system. Provide a written description for each requirement that the system cannot meet or can partially meet.

2.2.9 Cost Proposal

Provide a complete cost proposal for the three deployment scenarios identified in Section 1.2. The Cost Proposal form is included in Appendix E – Cost Proposal Form. The cost proposal form provides the minimum itemized list and breakdown that shall be included in the cost proposal. Proposers are encouraged to provide detailed cost breakdown for the ATSPM system deployment.

2.3 Disadvantaged Business Enterprise (DBE) Requirement

This project is financed in part or in full by federal funding, in which case federal third-party contracting requirements shall apply. Effective July 2012, the California Department of Transportation (Caltrans) requires recipients of DOT grant funds through Caltrans to impose the DBE utilization requirements on its consultants and contractors. DBE participation on this Agreement will assist Caltrans in meeting its federally mandated statewide overall DBE goal. The DBE goal for this project is 0%, but DBE participation is encouraged.

3 SELECTION PROCEDURES

3.1 Minimum Qualifications

Minimum qualifications of the Proposer are to ensure the City implements a time-tested and quality ATSPM system. To be considered qualified, the Proposer must demonstrate that the following minimum qualifications, including compliance with instructions governing the proposal submission requirements, are met as part of the proposal:

- Proposer shall have at least two years of experience implementing ATSPM systems.
- The proposed ATSPM system must meet the system requirements as included in Appendix B. The proposed ATSPM system must be off-the-shelf software with a minimum of three successful deployments of similar scope.
- Proposer shall have existing customer service support office and personnel.

Proposers failing to meet the minimum qualifications will not be considered.

3.2 Review of Proposals

The selection process will involve evaluating all qualified proposals received by an evaluation panel and based on the following evaluation criteria.

CRITERIA	MAX POINTS
1. Project understanding and approach – This is an assessment of the Proposer's understanding of the existing system and approach to utilize existing communication and traffic signal system to provide complete ATSPM capabilities.	30
2. Firm qualification, system capability, and client reference. – This is an assessment of the Proposer's overall qualifications including relevant firm experience, user friendliness of the system, capabilities of the system, and feedback from existing clients/users.	25
3. Implementation Schedule to deliver a complete operational system. – This is an assessment of the realistic estimate of implementing a fully functional ATSPM system, including City's estimate of time need to implement all infrastructure improvements (based on Proposer's input) plus the Proposer's estimate to deploy an ATSPM system.	10
4. Proposed System Integration cost, including maintenance and licensing cost. – This is an assessment of total implementation cost for the system, including annual maintenance cost of the system in short-term (3 years) and long-term (10 years).	25
5. Systems commitment to research and development, ease of expandability and openness to integrate with futuristic and innovative features. This is an assessment of the Proposer's overall system and how easily additional and futuristic innovative solutions (example integration with Waze/Google, adding Origin-Destination modules, etc.) can be added to the ATSPM system.	10
TOTAL	**100**

The evaluation panel will score each proposal based on the evaluation criteria**.** Based on the review of the proposals submitted, the City may choose to shortlist a select number (no more than 3) of the highest-ranked Proposers for an interview and demonstration of the proposed system. The interview and demonstration will be used by the evaluation panel to clarify and expand on information submitted in the written proposal. The City may elect to skip the presentation and demonstration process. This may occur based on the quality and quantity of proposals submitted, and the City may select a Proposer based solely on the written proposals submitted.

3.3 Interview of Proposers

The shortlisted Proposers will be asked to demonstrate its system by presenting a working version of the proposed system. The demonstration should highlight the proposed system's basic ATSPM functionalities, monitoring capabilities, reporting capabilities, and any other features the Proposer feels would demonstrate the advantage of the proposed system to the evaluation panel, including ease of integration with futuristic innovative technologies. The product demonstration will be held at the City's Public Works office. The Proposer must provide all hardware and software components in order to demonstrate the proposed system to the selection panel. The interview and demonstration will be used by the evaluation panel to clarify and expand on information submitted in the written proposal. The Proposer's project manager, as well as other key staff identified in the Proposer's organization chart, will be expected to participate in the interview and demonstration.

3.4 Estimated Schedule for Selection

Activity	Date/Time
1. Request for Proposal (RFP) Released	August 19, 2019
2. Deadline to Submit Questions	August 29, 2019 at 4:00pm
3. Response to Questions	September 6, 2019
4. Proposal Due	September 16, 2019 at 4:00pm
5. Interview of Proposers	October 1, 2019
6. Selection of Recommended Proposer	October 14, 2019
7. Contract Award	November 25, 2019

4 SCOPE OF SERVICES

The ATSPM System Vendor ("Vendor") shall furnish, install, integrate, and test all necessary software and hardware/equipment, and make operational an ATSPM system that will enable the City to make informed decisions about strategies to manage their traffic signals and measure the performance of the intersections and project corridors. The ATSPM system will allow the City to address problems proactively – instead of a reactive, complaint-driven approach – and to operate signals efficiently within the constraints of limited staff. The Vendor shall be responsible for all items necessary to furnish, install, configure, implement, test, and provide training and documentation on the proposed system.

The Vendor shall be fully responsible for the maintenance and care of all hardware/equipment and software furnished by the Vendor until the time of final acceptance of the ATSPM system by the City.

4.1 Project Management

The Vendor shall designate a dedicated Project Manager that will be committed to this project to fulfill the responsibilities described in this Scope of Work. The Project Manager's responsibilities shall include, but not be limited to, the following:

- Coordinate the work of this contract with other concurrent work, as necessary.
- Maintain regular communication with City staff.
- Maintain an adequate staff of qualified support personnel to perform the work necessary to complete the project.
- Maintain contract administration consistent with federal requirements, including monitoring of project status and project budget

4.1.1 Project Schedule

The Vendor shall develop and maintain a project schedule for the duration of the project. Within one week after the Notice to Proceed (NTP), the Vendor shall submit a detailed schedule indicating all milestone dates and major deliverables. The City will review and approve the Project Schedule for content and format. Upon approval of the Project Schedule, the Vendor shall update the Project Schedule at least on a bi-weekly basis to reflect actual progress.

4.1.2 Bi-weekly Progress Meetings

The Vendor shall arrange and attend bi-weekly project meetings/calls with City staff and other project stakeholders to discuss project status, schedule, forecasted work, issues, etc., until the final acceptance of the ATSPM system by the City.

4.2 FURNISH ATSPM SYSTEM

The Vendor shall furnish an ATSPM system at the 54 project intersections per the Final System Requirements document attached to this RFP as Appendix B. This includes any software, hardware/equipment (if applicable), licenses, applications, servers, and other utilities for the

operation of the ATSPM system. Any ancillary equipment or supplies needed to install applicable hardware/equipment, including cabling, mounting brackets, etc. must be provided by the Vendor.

4.3 INSTALLATION, INTEGRATION, AND DEPLOYMENT

The Vendor shall install, configure, and integrate the ATSPM system on the City's workstations, tablets, and/or mobile devices that are authorized by the City's IT department. The Vendor shall provide documentation on the specifications and locations of any servers, if applicable, including redundancy and security for any storage device or server that houses any City data.

The Vendor shall configure up to five (5) user accounts with customized user privileges. In addition, at the locations within this project, the Vendor shall integrate all existing traffic signal controllers, existing detectors, system parameters, signal timing, and appropriate field conditions, as necessary, for the accurate reporting of performance measures.

4.4 SYSTEM TESTING AND ACCEPTANCE

The Vendor shall develop Verification and Acceptance Test Procedures for the City to review, based on the Final Verification Plan document attached to this RFP as Appendix C. The Vendor shall provide the Acceptance Test Procedures to the City at least 15 working days before testing is scheduled to begin. Verification and Acceptance testing shall not begin until the procedures have been approved by the City.

The Acceptance Test Procedures shall serve as a guide to operationally test the system. The Acceptance Test Procedures must map to at least one of the system requirements, and all requirements must have a procedure associated with it. The Acceptance Test Procedures must describe the means, methods, tools, and acceptance criteria to verify that the system is working as designed. They should also describe any information needed from the City, any impact to normal daily operations, and describe normal operating conditions and failure conditions.

The testing shall include tests for the ATSPM software, any hardware/equipment associated with the ATSPM system, communications, detection inputs, IT equipment, and traffic signal controller equipment necessary for the operation of the ATSPM system. In the event of errors, the City may choose to temporarily end further testing until the errors have been resolved. The final testing shall demonstrate:

- All system requirements have been met.
- The user interface is configured properly for all use cases.
- The system is storing and retrieving data per the requirements.
- The system is free of errors.
- The integration with the City's traffic signal controller equipment is free of errors and is not impacting normal operations of the traffic signal equipment.
- Reporting functionality is working.
- Security measures have been demonstrated.

- The system can be updated remotely free from errors.

All testing shall be conducted by the Vendor and observed by the City or its designee. The Vendor shall document, and submit to the City, the test results with any additional actions needed for acceptance explained in detail. Upon approval by the City, the City shall declare acceptance of the system and will be responsible for maintenance of the system upon acceptance. The acceptance date will mark the beginning of the Vendor's warranty period. The final acceptance would be completed within 20 working days from the installation of the system.

4.5 TRAINING AND TRAINING DOCUMENTATION

The Vendor shall provide two training sessions for City staff. The first training session is anticipated to occur when the system is initially deployed, with the second session occurring 6-12 months later at the City's discretion. Training shall include all aspects of operating, maintaining, and administering the ATSPM system. It shall include setting up user accounts, reporting, troubleshooting, among other aspects.

The Vendor shall submit a training plan to the City for review and approval 30 days prior to the start of training. The training materials shall include all reference materials, procedures, and manuals that will be used. The training plan shall include the method for delivering the training, any requirements for the City to provide (room space, access to equipment, etc.) and the detailed agenda with timing for the training.

The training shall be a combination of classroom instruction and hands-on interaction with the ATSPM system and hardware/equipment, if applicable. All training shall be conducted during the normal business hours of the City.

4.6 ATSPM SYSTEM DOCUMENTATION

The Vendor shall provide documentation for all software (and hardware/equipment, if applicable) components of the system. The Vendor shall also provide standard operating procedures. The documentation shall be submitted to the City for review and approval before acceptance. Following approval, the Vendor shall provide a minimum of five (5) copies of all documentation to the City.

4.7 SYSTEM LICENSE, WARRANTY, AND SUPPORT

4.7.1 Licenses

The Vendor shall provide all licenses required for the operations and maintenance of the system, including, but not limited to, third-party software applications, databases, network components, and servers (if applicable) for the unlimited use by the City. The terms and conditions of any software license will be incorporated into the final contract. Prior to finalizing the contract, the City reserves the right to negotiate terms of the software license.

4.7.2 Warranty

The Vendor shall provide a warranty for three (3) years for all software (and hardware/equipment, if applicable) components. The terms of the warranty will be

incorporated into the final contract and shall include all software bug fixes, patches, software updates, and additional features for the life of the warranty.

The Vendor shall coordinate in advance of updating the software, including scheduling time for any updates that will cause the software to be inaccessible. If applicable, the Vendor shall repair/replace any inoperable hardware/equipment in a timely manner during the warranty period to minimize any disruptions to City operations.

4.7.3 Technical Support

The Vendor shall provide technical support to the City for the life of the warranty. Technical support includes, but is not limited to, the following:

- Troubleshooting of the system
- Routine questions
- Configuration questions or changes
- Customized reporting

The Vendor shall provide in the contract the support terms, including response times, communication methods, and hours of availability.

4.7.4 Maintenance agreement

The Vendor shall include a maintenance agreement and associated cost to the City for the life of the warranty as part of the proposal. The maintenance agreement can be included in appendix, but it should be included as a line item for the cost proposal. The maintenance agreement should explain all items covered as part of the maintenance agreement and the projected cost beyond the warranty period for 10 years.

APPENDIX A– Concepts of Operations

Innovative Deployment to Enhance Arterials (IDEA) Category 1

City of San Rafael – Automated Traffic Signal Performance Measures (ATSPM)

Final Concept of Operations (ConOps)

Prepared by:

DKS

Version 2.0

June 4, 2019

Document Control Panel					
Version Number	Author(s)	DKS QC	Reviewer(s)	Submittal Date	Document Description
1.0	Elliot Hubbard	Pam O'Brien	Linda Lee, Lulu Mao	1/29/19	Pre-Draft ConOps
1.1	Pam O'Brien	David Mahama	Rafat Raie, Hunter Young	2/8/19	Draft ConOps
2.0	Elliot Hubbard	Pam O'Brien		6/4/19	Revised Draft

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1 Scope

1.1 Document Purpose and Scope

This Concept of Operations (ConOps) document discusses an Automated Traffic Signal Performance Measures (ATSPM) system for use at up to 54 intersections, shown in Figure 1 and listed in Table 1, within downtown San Rafael. Specifically, this ConOps report:

- Describes the rationale for the expected operations of the proposed ATSPM system.
- Documents the outcome of stakeholder discussions undertaken to ensure that the system implemented is operationally feasible and has the support of its stakeholders.
- Addresses an audience of system operators, administrators, decision-makers, non-technical readers, and other stakeholders.

1.2 *Project Purpose* and Scope

The purpose of the project is to deploy operational tools that will enable the City to make informed decisions about strategies to improve their traffic signals and the operations of the project corridors. With the ATSPM system, the City seeks the capability to address problems proactively—instead of a reactive, complaint-driven approach—and to operate signals efficiently within the constraints of limited staff.

The tools that will be deployed as part of this project include an ATSPM system as well as any vehicle and/or pedestrian detection necessary for each performance measure.

The City of San Rafael is proposing to procure a commercially-available, off-the-shelf ATSPM system. Configuration of up to 54 signalized intersections within the City's downtown area will allow the City to collect high-resolution data and proactively manage the traffic signal network. The final intersection count may be adjusted to fit within the project budget, given the vehicle and pedestrian detection infrastructure that may be needed.

Any traffic signal connected to the ATSPM system will need to allow for the collection of high-resolution data in each lane. The City is actively working to bring all traffic signal controllers in the project area on to the Econolite Centracs centralized traffic management system via high speed communications. Should a traffic signal not be connected to Centracs, a phased deployment of the ATSPM system may be necessary, targeted initially to those intersections with upgraded controllers and existing connections to the Centracs central system.

Figure 1: System Project Limits

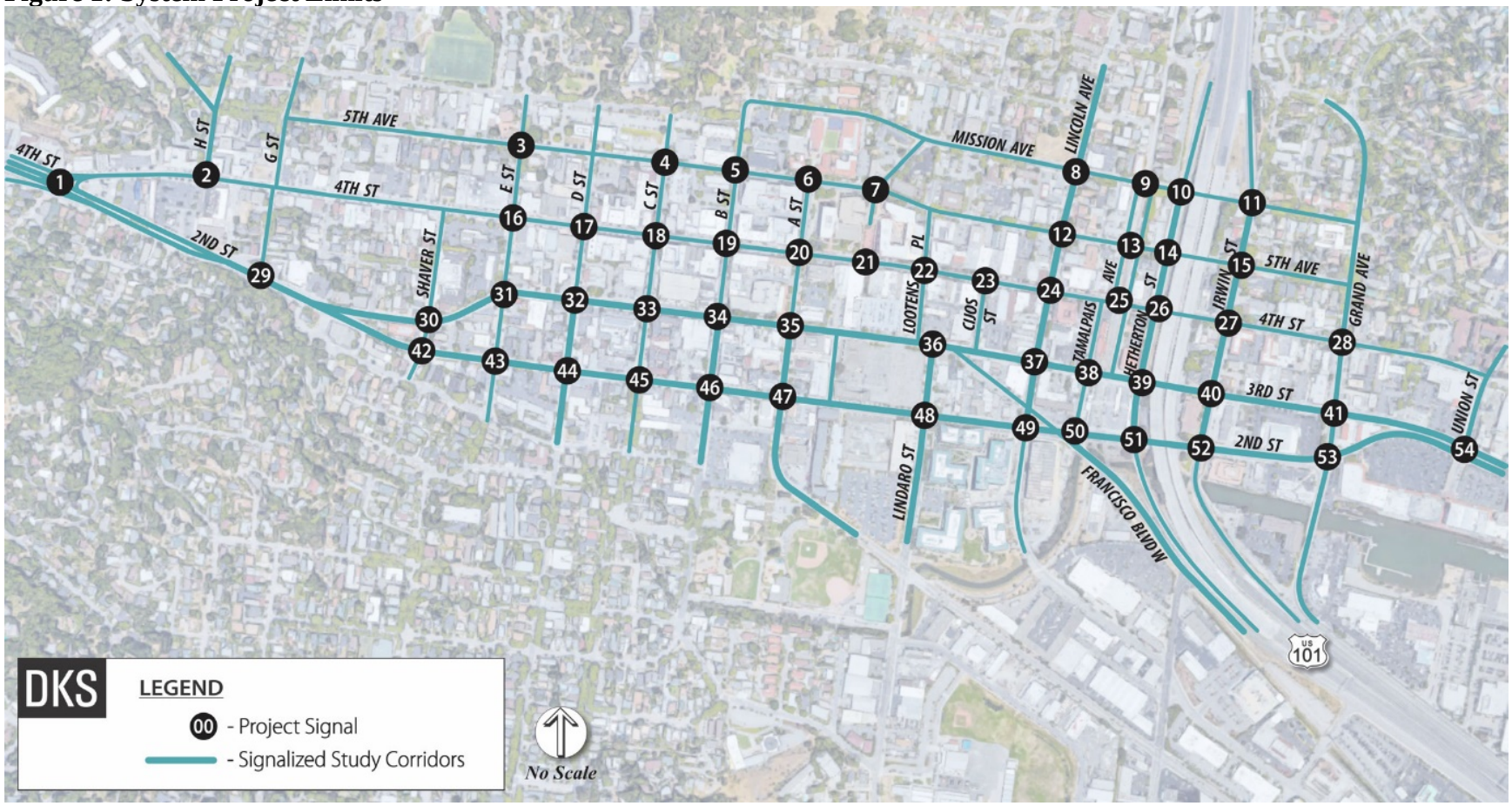


Table 1: Project Intersections

Int. No.	Intersection
1	2nd Street & 4th Street
2	4th Street & H Street
3	5th Avenue & E Street
4	5th Avenue & C Street
5	5th Avenue & B Street
6	5th Avenue & A Street
7	5th Avenue & Court Street
8	Mission Avenue & Lincoln Avenue
9	Mission Avenue & Tamalpais Avenue
10	Mission Avenue & Hetherton Street
11	Mission Avenue & Irwin Street
12	5th Avenue & Lincoln Avenue
13	5th Avenue & Tamalpais Avenue
14	5th Avenue & Hetherton Street
15	5th Avenue & Irwin Street
16	4th Street & E Street
17	4th Street & D Street
18	4th Street & C Street
19	4th Street & B Street
20	4th Street & A Street
21	4th Street & Court Street
22	4th Street & Lootens Place
23	4th Street & Cijos Street
24	4th Street & Lincoln Avenue
25	4th Street & Tamalpais Avenue
26	4th Street & Hetherton Street
27	4th Street & Irwin Street

Int. No	Intersection
28	4th Street & Grand Avenue
29	2nd Street & G Street
30	3rd Street & Shaver Street
31	3rd Street & E Street
32	3rd Street & D Street
33	3rd Street & C Street
34	3rd Street & B Street
35	3rd Street & A Street
36	3rd Street & Lindaro Street
37	3rd Street & Lincoln Avenue
38	3rd Street & Tamalpais Avenue
39	3rd Street & Hetherton Street
40	3rd Street & Irwin Street
41	3rd Street & Grand Avenue
42	2nd Street & Shaver Street
43	2nd Street & E Street
44	2nd Street & D Street
45	2nd Street & C Street
46	2nd Street & B Street
47	2nd Street & A Street
48	2nd Street & Lindaro Street
49	2nd Street & Lincoln Avenue
50	2nd Street & Tamalpais Avenue
51	2nd Street & Hetherton Street
52	2nd Street & Irwin Street
53	2nd Street & Grand Avenue
54	3rd Street & Union Street

1.3 *Procurement*

The procurement of any project elements funded through the City's MTC IDEA grant - including any designed elements, ITS roadway components, construction support, system software or hardware, or other equipment necessary for the successful deployment of the ATSPM system—will be in accordance with the City's contracting documents for federally-funded projects, including City Design Standards and any ATSPM project specific Technical Special Provisions. The ATSPM system will be procured through a Request for Proposal (RFP) process to select a system vendor.

Separately from this MTC IDEA grant-funded project, the City is investing in communications, controller, and detection improvements that may be used to support the project's deployed ATSPM solution. The funding and procurement of these improvements are outside the scope of the ATSPM project.

Anticipated procurement roles and responsibilities for key stakeholders are shown in Table 2 below:

Table 2. ATSPM System Procurement Roles and Responsibilites

Stakeholder	Role/Responsibility
San Rafael	• Develop procurement documents • Assist with development of proposal evaluation criteria • Select system vendor(s) • Negotiate and finalize vendor contract(s) for the ATSPM product, detection equipment upgrades, and maintenance contractor
MTC	• Assist with development of proposal evaluation criteria • Assist with proposal review and evaluation
DKS	• Develop technical requirements for use in procurement documents • Assist with the development of proposal evaluation criteria • Assist with proposal review and evaluation

2 Referenced Documents

- "Performance-Based Management of Traffic Signals – Phase 1 Report", National Cooperative Highway Research Program (NCHRP) Project 03-122, Transportation Research Board, 2017.
- "Performance Measures for Traffic Signal Systems, An Outcome-Oriented Approach", C. Day, D. Bullock, H. Li, S. Remias, A. Hainen, R. Freije, A. Stevens, J. Sturdevant, T. Brennan, 2014.
- "Integrating Traffic Signal Performance Measures into Agency Business Processes", C. Day, D. Bullock, H. Li, S. Lavrenz, W. Smith, J. Sturdevant, 2015.

3 Background

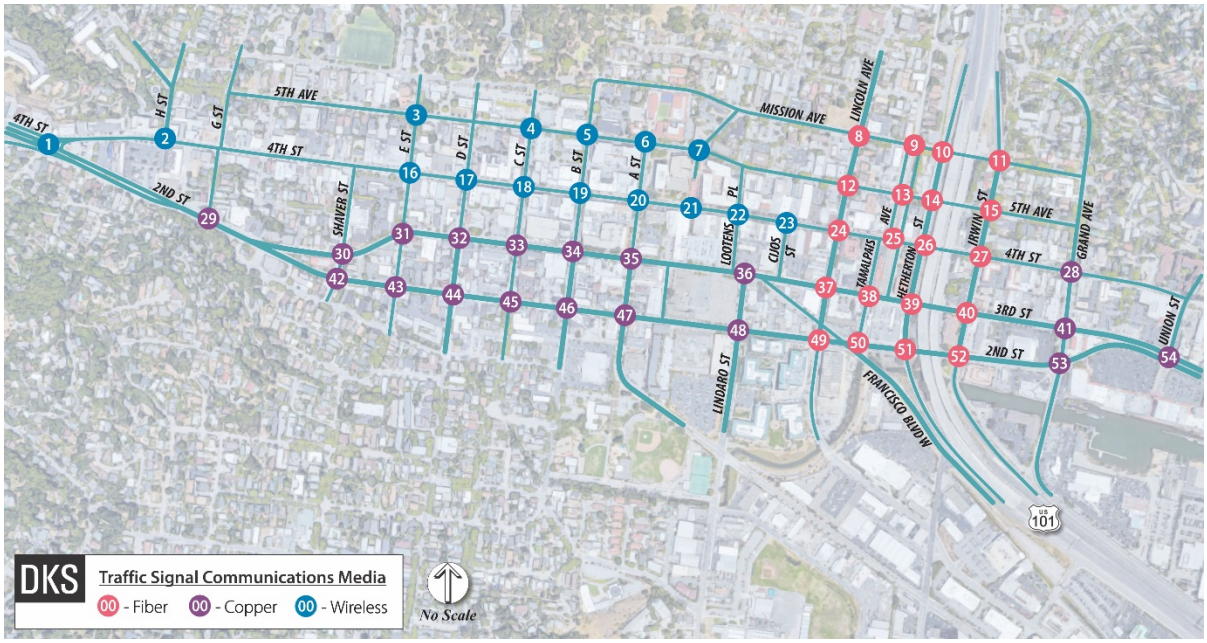
This section describes the existing signal system infrastructure and operations along the project corridors, including limitations of the existing system, proposed improvements, and goals/objectives of the new ATSPM system.

3.1 Existing Situation

3.1.1 System Architecture

Currently, the City operates traffic signals utilizing two centralized traffic management systems — Econolite Centracs and Aries. The City is actively working to phase out the legacy Aries system. Of the 54 signalized intersections within the project limits, 26 (from Mission Avenue to 2nd Street, Lincoln Avenue to Union Street, including 2nd Street/Lindaro Street and 3rd Street/Lindaro Street) are managed by Centracs and utilize high-speed communications[1]. The remaining 28 signals are managed by Aries and utilize a dial-up connection for communications. It is anticipated that by the time the City enters construction to install the ATSPM system, many of these remaining signals will be managed by Centracs. Figure 2 shows the communication media in place as of this writing.

Figure 2: Existing Communications Media



Centracs-managed intersections require the use of Econolite Cobalt or ASC3 controllers while Aries-managed intersections utilize Econolite ASC2, CBD6000, and ASC 8000 controllers. Of these, only the Cobalt and ASC3 controllers are capable of collecting high-resolution controller data.

[1] As of September 2018.

As part of a previously planned upgrade of the 28 controllers connected to the Aries system, Cobalt ATC controllers will be installed and they will be connected to the Centracs system with high-speed communications.

3.1.2 Signal Coordination Characteristics

Most of the traffic signals within the downtown grid operate in fixed-time mode. These signals are closely spaced making it very challenging to optimally serve all traffic movements all the time. Additionally, railroad preemptions at the interactions on Tamalpais Avenue, parallel to the railroad tracks from Mission Avenue to 2nd Street, present unique constraints on signal coordination. The preemption events impact traffic on nearby streets by blocking the east/west movements, causing excessive queuing at times. The City anticipates this situation will be exacerbated in the near future as a result of the planned at-grade crossings on 2nd Street and 3rd Street as part of the SMART train extension.

Queue Cutter Operations

The traffic signals on Tamalpais Avenue at Mission Avenue, 5th Avenue, and 4th Street also operate as queue cutter signals under specific circumstances. For example, when a downstream traffic signal is red, a queue begins to form at the downstream signal. Should said queue back up and approach the railroad tracks, the queue cutter function will turn the signal at the tracks red, thus forcing the queue to be located on the nearside of the railroad tracks rather than queuing directly on top of the tracks. Furthermore, electronic blank-out signs restrict turning movements during the queue cutter function or railroad preemption. These restrictions constrain signal coordination operations and impact traffic flow.

Pre-Signal Operations

On 2nd Street and 3rd Street at the railroad tracks, the City will install pre-signals to reduce the possibility of vehicles queuing across the tracks when a downstream signal is red. This work is scheduled to be in place by Summer/Fall 2019 prior to train testing of the Larkspur Extension from Downtown San Rafael to Larkspur. The pre-signals will not be standalone traffic signals, but rather, connected to existing traffic signals at 2nd Street/Hetherton Street or 3rd Street/Tamalpais Avenue as field conditions dictate.

3.1.3 Detection Characteristics

The majority of signalized intersections in the downtown grid have no vehicle detection. Exceptions include:

- Tamalpais Avenue/Mission Avenue (video detection and queue loops)
- Tamalpais Avenue/5th Avenue (video detection and queue loops)
- Tamalpais Avenue/4th Street (video detection and queue loops)
- Mission Avenue/Lincoln Avenue EB Left Turn (loops)
- 3rd Street/Union Street (video detection)
- 5th Avenue/E Street (loops on E Street only)
- 5th Avenue/C Street (loops on C Street only)
- 2nd Street/G Street (video detection)
- 2nd Street/4th Street (video detection)

- 4th Street/H Street (video detection)
- Hetherton Street/Mission Avenue (MioVision single camera)
- Hetherton Street/2nd Street (MioVision single camera)
- Irwin Street/2nd Street (MioVision single camera)
- 2nd Street/Grand Avenue (MioVision single camera)

Pedestrian detection exists at the following intersections:

- Tamalpais Avenue/Mission Avenue
- Tamalpais Avenue/5th Avenue
- Tamalpais Avenue/4th Street
- Hetherton Street/Mission Avenue
- Hetherton Street/5th Avenue (west leg only)
- Hetherton Street/4th Street (west leg only)
- 2nd Street/G Street
- 2nd Street/4th Street
- 4th Street/H Street
- 2nd Avenue/Irwin Street
- 2nd Avenue/Hetherton Street
- Irwin Street/Mission Avenue
- 3rd Avenue/Union Street

3.1.4 Staffing/Maintenance Characteristics

The City has limited engineering staff to manage the existing traffic signal system. To augment City forces, the City relies heavily on a third-party electrician (DC Electric) for routine maintenance. The City also utilizes a maintenance contract with Econolite for troubleshooting specific issues inside of traffic signal controller cabinets.

3.1.5 Project Corridor Characteristics

As described in Section 1, the Concept of Operations Report focuses on the Downtown area. The existing characteristics of the primary corridors and activity centers are summarized as follows:

2nd Street and 3rd Street (couplet)

- Eastbound and westbound "pipeline" or through-put responsible for high volumes of vehicles east and west through San Rafael to West County
- Intersects Hetherton Street/Irwin Street couplet

4th Street

- Provides access to the downtown businesses district
- Vehicle speeds are slower
- High pedestrian volumes

Hetherton Street and Irwin Street (couplet)

- Frontage roads and access points to/from US-101

- Provide access to/from the downtown grid
- Very high traffic volumes
- High pedestrian volumes near the San Rafael Transit Center, SMART commuter rail station, and San Rafael High School
- Intersects the 2nd Street/3rd Street couplet

Tamalpais Avenue

- Parallel to Hetherton Street and the SMART train tracks and provides local access
- Signals are frequently preempted by the SMART train
- Very short block spacing causes queuing
- Signals on Tamalpais Avenue act as queue cutters

SMART Transit station area

- SMART train preempts signals along Tamalpais Avenue at 4th Street, 5th Street, and Mission Street. Preemption is tied to signals on Hetherton Street as well as Lincoln Avenue
- High pedestrian volumes
- For southbound Hetherton Street, No Right Turn signs turn on when conflicting pedestrian phase is served
- High bus volumes on 2nd Street, 3rd Street, Hetherton Street, and Irwin Street
- A new SMART station in Larkspur will open in late 2019. This will extend the railroad tracks across 2nd Street and 3rd Street, preempting the traffic signals.

3.2 Limitations of the Existing System

The existing system does not provide the systematic analysis and performance monitoring capabilities necessary to operate the traffic signals in the most efficient manner and meet the City's mobility goals.

Limitations of the existing system include:

- Difficult to measure/determine if the signal timing is operating as designed.
- Two signal systems (Centracs and Aries) operate on different background clocks, which causes a constant time drift between the two. This results in signal coordination being thrown off
- The majority of signals are not wired to accept pedestrian actuations
- Only a few signals have vehicle detection
- Many signals do not have the ability to accept typical video detection due to lack of mast arms
- Communication connections are susceptible to weather impacts
- Lack of insight into the impacts of train preemptions on traffic operations.
- The existing system does not provide a means to track traffic flow during incidents or how long it takes to clear congestion.

- Excessive manual maintenance activities required with respect to the current resource-constrained staffing environment (i.e. no support for automating various maintenance tasks).

3.3 Proposed Improvements to the Existing System

An ATSPM system presents a unique opportunity to address the limitations of the existing system. The following statements describe the City-desired improvements:

- Automate the collection of high-resolution signal performance data from key signals and corridors
- Provide centralized access to signal performance measures and analytics
- Provide reports and other tools suitable for helping users to identify operational issues, assess signal system performance, and recommend optimizations and improvements
- Support future integration of other performance data sources, including external travel time systems

3.4 Vision, Goals, and Objectives

The vision of the ATSPM system is to provide a cost-effective performance measurement system that ensures safe and efficient mobility regardless of mode choice.

The goals of the ATSPM system are to:

- Maximize signal efficiency for all users
- Report on impacts of train preemptions and recommend recovery operations
- Proactively monitor and report on equipment and sensor health
- More efficiently allocate available green time for multi-modal services (pedestrian, bicycle, and transit).

3.4.1 Corridor-specific Operational Objectives

This section identifies the key operational objectives specific to the project corridors (see Table 3). In addition to the objectives identified above, these corridor-specific objectives will help the City determine the appropriate traffic signal operational strategies suited to the corridor.

Table 3. Key Objectives by Project Corridor

Corridor	Corridor-specific Objectives
2nd Street	• Maximize eastbound throughput, especially during the a.m. peak period • Maximize eastbound travel time reliability • Minimize eastbound and northbound queues at Irwin Street

Corridor	Corridor-specific Objectives
	• Maintain reasonable access for bicycles and pedestrians to cross the arterial
3rd Street	• Maximize westbound throughput, especially during the p.m. peak • Maximize westbound travel time reliability • Minimize westbound and northbound queues at Irwin Street • Minimize westbound and southbound queues at Hetherton Street • Equitably distribute green time at Union Street • Maintain reasonable access for bicycles and pedestrians to cross the arterial
4th Street	• Minimize pedestrian delay • Maintain reasonable vehicle progression • Minimize railroad preemption impact at Tamalpais Avenue
Hetherton Street	• Maximize southbound throughput, especially during the a.m. peak • Maximize southbound travel time reliability • Minimize westbound and southbound queues at 3rd Street
Irwin Street	• Maximize northbound throughput, especially during the p.m. peak • Maximize northbound travel time reliability • Minimize eastbound and northbound queues at 2nd Street
Tamalpais Avenue	• Minimize railroad preemption impact at Mission Avenue, 5th Avenue, and 4th Street
Citywide	• Maximize multimodal (bike, ped, transit) operations at specific locations (determined by City plans)
Railroad Preemption	• Minimize delay due to SMART train preemption • Minimize recovery time to progression during and after train preemption

4 Operational Needs

This section describes the operational needs identified by the City of San Rafael related to the operations of the ATSPM system. The User Needs describe what the system needs to do that is not currently supported by the existing traffic signal system.

4.1 User Need Categories

The User Needs identified were grouped into six categories as shown in Table 4. Each User Need has been assigned a category and number, which provides a method to trace the need through to the system requirements, which will be developed later.

Table 4. User Need Categories and Abbreviations

Category	Abbreviation	Description
Operations	NOP	User needs related to the operations of the traffic signal
Planning	NPL	User needs related to collecting and tracking data and trends
Reporting and Documenting	NRD	User needs related to the performance measures reports
Network and Access	NAR	User needs related to the system network and access
Maintenance	NMT	User needs related to system maintenance and support
Other	NOT	User needs not included in the other categories

4.2 User Needs

The User Needs, shown in Table 5, were developed based on discussions with the City and the Metropolitan Transportation Commission (MTC).

Table 5. ATSPM System User Needs

Number	User Need
NOP-1	The user needs to know when a phase is not long enough to serve the demand on a consistent basis (i.e., phase failure).
NOP-2	The user needs to know when a phase gaps out, maxes out or is forced off.
NOP-3	The user needs to know where there are high delays on specific approaches.
NOP-4	The user needs to know how efficient the progression is along a corridor.
NOP-5	The user needs to know how railroad preemption impacts the nearby traffic signals and its system-wide impacts.

Number	User Need
NOP-6	The user needs to know when the queue cutter signals are enabled and disabled.
NOP-7	The user needs to know when and how long the No Right Turn blank out signs are active.
NOP-8	The user needs to know when large queues form at specific locations.
NOP-9	The user needs to know when each coordinated timing plan was active
NOP-10	The user needs to know when a traffic signal is in transition.
NOP-11	The user needs to know the length of each phase and cycle.
NOP-12	The user needs to know when the pedestrian push buttons are activated
NOP-13	The user needs to know when communications to the traffic signals fail.
NOP-14	The user needs to know when the intersections go into Flash mode.
NOP-15	The user needs to collect travel time along select arterials.
NPL-1	The user needs to collect, report and track vehicle volume data.
NPL-2	The user needs to collect, report and track bicycle volume data.
NPL-3	The user needs to collect, report and track number of railroad preemptions.
NPL-4	The user needs to collect, report and track length of railroad preemptions.
NPL-5	The user needs to collect, report and track pedestrian volume data.
NRD-1	The user needs to retrieve data from the local controllers and create the performance measure reports.
NRD-2	The user needs reports that are customizable by timeframe and data interval.
NRD-3	The user needs to produce both automated reports and reports based on a specific query.
NRD-4	The user needs to access near real-time logs (within five minutes) to produce reports.
NRD-5	The user needs to produce reports that are high-level summaries for decision makers and detailed for use in operations and troubleshooting.
NRD-6	The user needs to store the logs, alarms, and reports for a set amount of time where they are easily accessible.
NRD-7	The user needs to produce performance measures based on the Purdue Data Set and show them graphically.
NRD-8	The user needs a dashboard that is configurable for each user and each of

Number	User Need
	the performance measures
NRD-9	The system needs to send alerts based on user defined triggers (using high-resolution data)
NRD-10	The system needs to produce reports that compare current operations to past performance for a given intersection.
NAR-1	The user needs to access the system from the City network and remotely via VPN.
NAR-2	The system needs to fully function between network security devices (i.e., fire walls).
NAR-3	The user needs access to full resolution data for a period of three years (fully query able). After three years, data may be compressed and archived to be stored indefinitely.
NAR-4	The user needs to receive alerts based on triggers via email or texts.
NAR-5	The user needs to collect data and produce reports on any City signal connected to the system.
NAR-6	Multiple users need to access the system at the same time.
NAR-7	The user needs to access the system via a smartphone.
NMT-1	The user needs vendor support for training and maintenance.
NMT-2	The user needs user manuals for system set-up, configuration, operations and maintenance.
NMT-3	The user needs on-call support for maintenance and troubleshooting issues.
NMT-4	The user needs to be notified of software revisions when they become available.
NMT-5	The user needs to know when detectors fail.
NOT-1	The system needs to be compatible with Econolite Cobalt and ASC3 traffic signal controllers.
NOT-2	If the system fails, the existing Centracs central traffic signal systems and local controllers shall not be negatively impacted.
NOT-3	The system needs to make recommendations for signal timing parameter changes.

5 System Overview

This section describes the envisioned ATSPM system to be deployed by the City of San Rafael. Elements include the system's main features and capabilities, the scope of its coverage, and other systems with which it will be interfaced.

5.1 System Features and Capabilities

The core function of the ATSPM system is the production of performance measures that provide useful and actionable insights into how the traffic signal network is performing. This section describes the internal system components required to obtain this data. The four key components are:

1. **Intersection components:** used to collect the intersection event data
2. **Communication:** wired or wireless infrastructure used to send event data to a management center
3. **Data architecture:** hardware and software components used to aggregate and organize data such that it can be analyzed
4. **Applications:** performance measurement and visualization software used to make sense of the structured data

Figure 3 provides an illustration of the key components required to support the ATSPM system architecture.

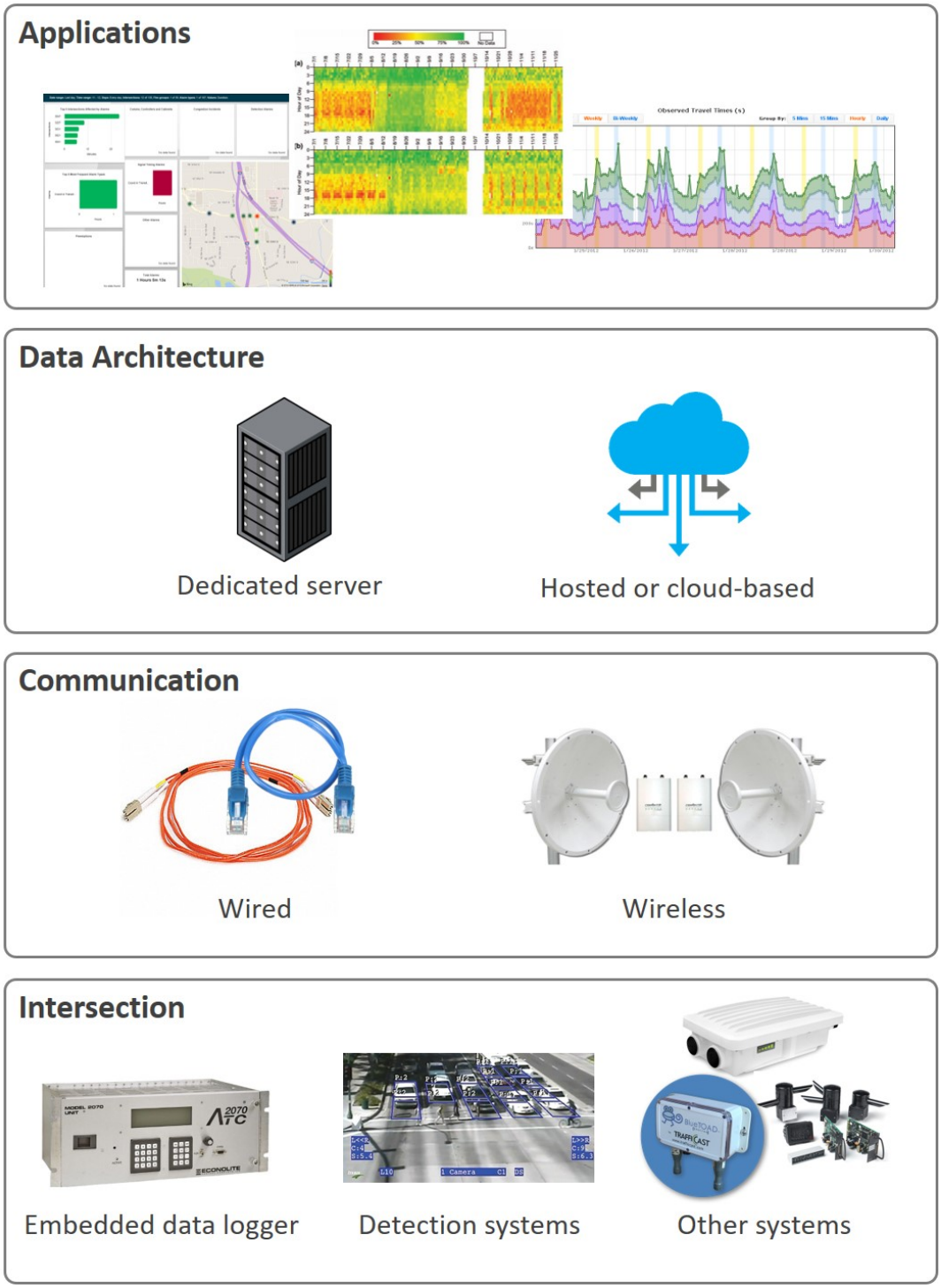


Figure 3: Components of an ATSPM System Architecture

5.1.1 Intersection Components

At the intersection level, the key ATSPM system function is the collection of state-change event data occurring in the intersection.

Data Logger
In order to collect state-change data of the signal controller, a data collection device at the intersection is necessary. Modern controllers, such as the City's Econolite ACS/3 and Cobalt ATC controllers, provide such a data logging capability.

Detection
Performance measures that incorporate vehicle data require a detection system that can sense the presence of vehicles within defined detection zones. Some performance measures, such as the percent Arrivals on Green, require point detection of each vehicle (i.e., count detection). The detection of transit vehicles, bicycles, and pedestrians may also be a capability of this detection system or may be part of a separate system.

Besides video and in-pavement inductive loops, typical options for detection technology are magnetometers and radar, neither of which is not currently used in San Rafael. As the adoption of connected vehicles (CV) becomes more widespread, CV applications may also be used as a source for vehicle data.

Railroad preemption is currently a source of detection for trains and is an input to the controllers along Tamalpais Avenue. Emergency vehicle preemption and transit signal priority control systems are also sources of vehicle detection that may be provided to the controller but are not currently being provided.

Detection Zones
Depending on the extent of detection for an intersection, certain signal performance measures may be attainable. In general, the more detection zones that are captured and the more capable the detection technology, the more performance measures that can be attained.

Lane-by-lane detection is generally preferable to calculate performance metrics at a higher level of detail, but it is not strictly required.

The three typical detection types are:

- Stop bar detection
- Advance detection
- Counts

Table 6 presents the key required/desired performance measures to be produced by the ATSPM system as determined through discussions with San Rafael stakeholders and indicates the minimum detection necessary to attain the given measure—stop bar (SB), advance (A), and/or counts (C). The count detector may be configured in advance or at the stop bar, wherever there is free flow traffic.

Table 6. Key ATSPM System Performance Measures and Required Detection

Category	Performance Measure	Required	Desired	Min. Detection Needed
Intersection Performance	Approach Delay	x		SB
	Split Monitor	x		*Not needed*
	Purdue Phase Termination	x		*Not needed*
	Purdue Split Failure	x		SB
	Detector Health	x		SB+A
	Yellow and Red Actuations		x	SB
	Coordination Mode Status	x		*Not needed*
Corridor Performance	Speed		x	A / [external syst.]*
	Arrivals on Green (Purdue Coordination Diagram)	x		A
	Arrivals on Red	x		A
	Travel Time	x		[external syst.]*
Multimodal	Pedestrian delay	x		Ped Push Button
	Pedestrian Volume		x	C
	Bicycle Volume		x	C
Preemption	Number of Preemptions	x		RR/EVP Detector
	Length of Preemptions	x		RR/EVP Detector
Planning	Vehicle Approach Volume	x		C
	Vehicle Turn Movement Counts		x	C
	Bicycle Volume	x		C

* Refer to Sec 5.2 for a discussion of external systems suited to collection of traffic-related data

5.1.2 Communication

Communications infrastructure and devices are used to transfer logged controller data from the intersection to a centralized location for processing and analysis. The signalized intersections in the project area are connected to the Traffic Management Center (TMC) via a mix of fiber, copper, and legacy radio systems.

5.1.3 Data Architecture

The processing, analyzing, and storing of traffic control system data obtained from the field is accomplished with centrally-located computer hardware and software components.

Various physical architecture options are available to support these functions, including on-premise servers housed at the traffic management center running database software or integrated cloud-based solutions that manage all aspects of the system.

The typical functions include:

- Data processing—normalizing and formatting data to be used for generating performance measures
- Data schemas—using database management systems to produce a data schema that organizes and stores data such that it is accessible, scalable, and useful to the users

5.1.4 Applications

The final step of the ATSPM system is in which the user accesses processed performance measures data through reports and visual displays. Software linked to, or packaged with, the central management system may provide such tools.

Commercial solutions are available today that provide standalone packages or web-based services to produce performance measures. Controller and detection system manufacturers as well as ATSPM-specific software companies all provide such ATSPM application solutions. The raw source code is also available for agencies to download, configure and manage.

5.2 Supporting Systems

The previous section described the key data collection components and functionality of the traffic control system. However, as illustrated in Table 6, some desired performance measures related to traffic performance are not available from the core system or may be better estimated by other applications.

For example, while it is possible to obtain accurate segment speeds from advance detection, these detectors must be installed and configured specifically with speed detection in mind—i.e., located at a sufficient distance upstream of the intersection and include dual loops or utilize radar. This setup is not typically the case on the project corridors.

Likewise, while possible to estimate travel time from detector and controller data, travel time performance measure calculations may be better suited to external systems. Such systems are described below.

5.2.1 Vehicle Re-Identification (e.g., Bluetooth readers)

Sensors used to identify and track unique vehicles as they progress through the transportation network represent a valuable detection approach to obtain vehicle travel times, average speeds, and even routing. Examples of such systems include Bluetooth and Wi-Fi readers deployed strategically along the corridors.

The integration point for this data may not be at the individual intersection signal controller level. Therefore, it is anticipated that the ATSPM system will need to provide an interface and support for incorporating external data sources into the performance measurement and reporting applications.

6 Operational Environment

The ATSPM system will be operated and monitored primarily from the workstations at the desks of transportation and support staff. City staff may also access the system remotely from portable devices. The ATSPM system will provide remote access and interface options for touch-based portable devices.

The City will continue to migrate its signals to the Econolite Centracs central traffic management system.

Any required on-premises server equipment will be housed at the Public Works building, to be determined by IT staff. In the case of a cloud-hosted solution, equipment will be hosted remotely by a third party.

The City has standardized on Econolite Cobalt ATC controllers, which are capable of collecting high-resolution data. This controller standard will be used for the ATSPM system. It is anticipated that ATSPM firmware and data logger upgrades will be included on all project intersection signal controllers. The City has likewise standardized on TS2 (Type 1 / Type "G") traffic signal control cabinets for project intersections.

The City will continue use of its IP-based communications network as is.

Where additional detection is needed for specific performance metrics, the City will install appropriate detection equipment.

Third-party travel time systems, while outside of the scope of this project, may also be installed to provide additional vehicle data. The data from these systems would be integrated with the ATSPM system.

The City expects to operate the turnkey ATSPM system with the latest software. The MTC IDEA program will cover the first three years; any remaining years would be covered by the City.

7 Support Environment

This section describes the support environment for the ATSPM system. Key elements include identifying institutions and stakeholders, facilities, system architecture constraints, equipment, computing hardware and software, personnel, and other support needs.

Stakeholders
Stakeholders of the ATSPM system include the City of San Rafael, the Metropolitan Transportation Commission (MTC), and the Transportation Authority of Marin (TAM). The City will be the owner of the ATSPM system to be deployed and will be responsible for the operation, management, and maintenance of the system. MTC is the funding agency and program manager of this initiative and is responsible for overall program oversight to ensure project delivery success. TAM is the sub-regional transportation agency and is responsible for coordinating funding for many of the transportation projects and programs in the County.

Facilities
The City's Engineering staff access the Centracs central traffic management system from Public Works, where all servers and networking equipment are currently located. The work

stations access the controllers via direct wired and wireless (backup) communications links. Depending on the architecture for the selected solution, the ATSPM system may be housed in the server room alongside and supported by the existing equipment or, in the case of a cloud solution, be hosted remotely as part of a fully-managed cloud solution.

System Architecture Constraints
The City's IT department, in conjunction with the City's Engineering staff, will provide support and system management to ensure that the ATSPM server or cloud platform is integrated into the City's existing communications network. Communications with signal controllers and other field devices will be provided using the existing Ethernet network and communications infrastructure.

Equipment
The City has all required equipment and resources to support the existing traffic signal system. Due to signal cabinet space constraints, the City's preference is for an ATSPM solution that does not require additional equipment to be installed in the cabinet.

Any additional equipment, software, or detection required to support the ATSPM system will be determined by the system vendor, subject to approval by the City. The vendor will be responsible for identifying and providing any hardware needed to support the ATSPM system, including servers and data storage. Other existing equipment that may be used to support the ATSPM system will be maintained and repaired by the City's IT staff. IT staff will also be responsible for software maintenance for standard software packages (e.g., computer operating systems, business applications).

Personnel
The ATSPM system will be operated by existing City Engineering staff that currently operate the central signal system. There are three full-time engineers and technicians. Additionally, contracted services include field service (Econolite), maintenance service (DC Electric), and ITS services (AMG). One full time engineer/project manager will be assigned for the duration of the project to coordinate internal resources and ensure the ATSPM system is deployed successfully. Training of Engineering staff will be required to be provided by the system vendor during and after the installation of the ATSPM system.

Key roles and responsibilities for the implementation and operation of the ATSPM system are identified in Table 7:

Table 7. Key ATSPM System Operational Roles and Responsibilities

Roles	Responsibilities
City Maintenance Staff	Configure and maintain cabinets and controllers as needed Configure and maintain detection equipment as needed Perform timing adjustments
City Engineering Staff City Signal Tech	Review data and reports Perform timing adjustments

Roles	Responsibilities
	Operate and maintain ATSPM system Review preemption data and reports Coordinate train preemption operations
City IT Engineer	Ongoing systems and network support

8 Operational Scenarios

This section presents several operational scenarios to illustrate how the ATSPM system is expected to operate to meet the User Needs as presented in Section 4. The scenarios describe how the user would interact with the system, with references to key ATSPM User Needs being addressed. Additionally, the scenarios identify the equipment components required to support the scenario as well as the key performance measure(s) and required detection.

Note that these are just a sampling of how the ATSPM system can be used by the City of San Rafael. Depending on the operational objectives of the corridors, City staff will review specific data and respond accordingly.

8.1 Operations: Monitor Intersection Performance and Optimize Timing

Motivation for scenario: This scenario represents a common situation that in current practice requires significant time by Signal Operations staff to manually compile and analyze data in order to investigate an operational issue, determine a solution, and evaluate its effectiveness. The ATSPM system enables the automation of much of this work, thus allowing staff to identify issues and implement solutions more rapidly and efficiently.

Overview: The City has been receiving complaints from drivers that during the peak period they were unable to clear the queue on the eastbound left turn (EBLT) movement at 3rd Street Union Street (Intersection #54). In this scenario, the ATSPM system is used to confirm and quantify the problem, determine how the controller is operating at this time and location, support development of a solution, and evaluate the performance after implementation.

Narrative:

- Signal Operations staff receive complaints from drivers who were unable to clear the queue on the EBLT movement at 3rd Street at Union Street (a protected left) during the a.m. peak period
- Operator accesses relevant historical performance measure reports for that intersection from the ATSPM system to confirm when this problem occurs, how long it lasts, and whether it is a trend or a one-day anomaly (NOP-1, -3, -8, -9, -11)
- Accessing the relevant diagrams/reports, Operator confirms that the problem starts at around 7:15 a.m. and lasts for an hour and recurs regularly during weekday; Operator also observes that the movement performs well at other times (NRD-2, -3, -5, -10)

- To investigate what the controller was doing at this time, the Operator accesses relevant reports to show the allocated green/red intervals over the course of the day and observes that the left turn phase maxes out during a.m. peak period and gaps out the rest of the time. (NRD-1, -2, -3; NAR-1, -4, -5)
- Based on the performance reports, Signal Operations staff develop a solution to enable a Max 2 time for the EB LT to operate during the a.m. peak and implements it (NOT-3)
- After two weeks, Operator runs a trend report on the intersection to compare the number of split failures before and after the signal timing change and observes a 30% reduction (NRD-10)
- Operator accesses reports for other movements and verifies change did not negatively impact them.

Assumed components:

- Traffic signal operates in fully-actuated mode.
- Econolite Cobalt ATC controller with ATSPM firmware
- Lane-by-lane (including left turn lane) stop bar detection with count capability at major and minor approaches
- Advance detection (loop or video, as needed) at major approaches

Key performance measures used:

Performance measure	Detection Required
Split monitor	-
Purdue phase termination	-
Purdue split failure	Stop bar
Arrivals on red	Advance
Vehicle turn movement counts	Count

8.2 Operations: Monitor Rail Preemption Occurrences

Motivation for scenario: Tamalpais Avenue signals are preempted each time a train arrives and departs the SMART station, which is located between 3rd Street and 4th Street on Tamalpais Avenue. The preemption events impact traffic on nearby streets by blocking the east/west movements and resulting in increased vehicle queueing. The ATSPM system will allow the user to quantify the impacts of preemptions and understand their extent so that better signal operations can be developed.

Overview: In this scenario, the ATSPM system is used to identify preemption occurrences at 4th Street and Tamalpais Avenue, assess impacts to progression on 4th Street, and to develop recovery operations strategies to minimize recovery time. Operator wants to determine when

the preemptions are happening and for how long. The Operator also wants to evaluate and test strategies to recover from the preemptions.

Narrative:

- Operator accesses ATSPM dashboard customized to present various summary railroad preemption performance measures (NRD-8; NPL-3, -4) to monitor trends in number and duration of preemptions.
- Operator selects preemption details report to review the occurrences of railroad preemption events for the previous week.
- Operator uses these event times to bound a review of signal operations and traffic performance measures to assess the traffic impacts on 4th Street during and after the preemption events.
- Operator observes that phases failures (high occupancy) for several cycles following the preemption, indicating that traffic is oversaturated for this movement
- Incorporating these observations, Signal Operations staff modify the preemption recovery strategy at the signals. Preemption recovery strategies may include serving a specific phase for a set amount of time after preemption, going directly to the point in coordination as if it wasn't preempted, or serving the phase that has waited the longest during preemption.
- Operator continues to monitor this location after timing is updated, accessing the performance measure reports to analyze before/after results (NRD-10)
- Operator observes that the number of phase failures decreased by 10% after implementation of preemption recovery

Assumed components:

- Econolite Cobalt controller configured for RR preemption and ATSPM
- Railroad preemption detection hardware
- Lane-by-lane stop bar detection with count capability at 4th Street approaches and at adjacent signalized intersections
- Advance detection (loop or video, as needed) at 4th Street approaches and at adjacent signalized intersections

Key performance measures used:

Performance measure	Detection Required
Number of railroad preemptions	Railroad preemption detector
Length of railroad preemptions	Railroad preemption detector
Arrivals on green	Advance

Performance measure	Detection Required
Yellow and red actuations	Stop bar
Split monitor	-
Purdue phase termination	-
Vehicle approach volume	Stop bar with count
Purdue split failure	Stop bar
Queue	Queue detector or camera

8.3 Maintenance/Troubleshooting: Identify Broken Detection and Unreliable Communication

Motivation for scenario: Typically, agencies rely on public calls or own observations to identify problems with equipment. ATSPMs can provide a number of heuristics to find such issues in an automated fashion and detect errors that may not be occurring during field visits, thus supporting a more proactive preventative maintenance program.

Overview: In this scenario, pre-configured automated alerts are emailed to the user to report on signal locations where detector errors were observed in the high-resolution data suggestive of equipment issues. Operator would use this report to address problems before there are substantial operational problems or public calls are generated. Similar reports can be generated for communication systems and other pieces of equipment.

Narrative:

- Traffic Engineer sets up automated reports to capture locations and phases in which any of the following occur (NRD-9):
    - Too many force-off occurrences (e.g., force offs = 100%)
    - Too many max out occurrences (max outs > 90%)
    - Too few records in database (no. records = 0)
    - Unusually low detector hits (counts < X [to be established based on historical averages for given location/phase/time])
    - Stuck pedestrian detectors (push buttons)
- Operator receives an automated alert that detector error conditions have been identified at the 2nd Street/A Street intersection
- Operator accesses the automated detector health report and observes that the A Street southbound approach stop bar detector has been flagged for error conditions (NMT-5)
- Operator selects a report for detector health to compare detector calls per hour for the last week overlaid with historical averages (NRD-10)
- Operator notes that detector reported zero calls during recent overnight periods, corresponding to low temperature; suggesting a bad cable losing contact

- Once repairs are made, Operator revisits detector health report and observes that calls are once again showing during overnight periods

Assumed components:

- Econolite Cobalt controller
- Side street vehicle and pedestrian detection (currently none)
- Stop bar detection

Key performance measures used:

Performance measure	Detection Required
Communications status	-
Detector health	Stop bar, advance

8.4 Multi-Modal Operations

Motivation for scenario: The downtown core of San Rafael serves a variety of transportation modes, including bus, rail, bicycles, and pedestrians in addition to automobiles. The traffic signals should serve all the modes in a balanced way. Historically, traffic signals are programmed based on the objectives of the automobile, because the data collected for non-automobile modes is limited.

Overview: In this scenario, the City is continually collecting data on bicycles and pedestrians and reviewing the traffic signal timing to balance/favor different modes.

Narrative:

- Intersections equipped with detection that collects volumes of bicyclists and pedestrians on each approach to the intersection (NPL-2, NPL-5).
- Traffic Engineer sets up automated reports to capture the volumes of bicycles and pedestrians associated with each phase (NRD-10).
- Traffic Engineer receives an automated daily report showing multimodal approach volumes in 15-minute intervals
- Traffic Engineer uses this information to adjust the pedestrian timings or phase split times at locations with high pedestrian volumes. The offsets are also modified to promote walking speed between signals.
- The Engineer reviews intersection split data to determine impacts of timing changes (NOP-2)
- Traffic Engineer reviews the reports routinely to track the multimodal volumes over time. (NRD-10)

Assumed components:

- Econolite Cobalt controller

- Detectors capable of collecting bicycle and pedestrian volumes.
- Stop bar detection

Key performance measures used:

Performance measure	Detection Required
Split monitor	-
Vehicle approach volume	Count
Bicycle approach volume	Stop bar with count
Pedestrian volume	Passive pedestrian detection

APPENDIX B – System Requirements

INNOVATIVE DEPLOYMENT TO ENHANCE ARTERIALS CATEGORY 1

City of San Rafael

Automated Traffic Signal Performance Measures

System Requirements

JULY 2019

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1 Scope

1.1 Document Purpose and Scope

The System Requirements establish the technical scope of the system to be deployed and will be incorporated into the RFP for the ATSPM system. The purpose of the requirements is to identify the technical and non-technical factors that may affect the process of selecting, developing, or modifying an ATSPM system. The requirements are also the basis for verifying (via the Verification Plan) the system that will be deployed.

The requirements are given discrete reference numbers and are measurable and testable individually. They are grouped into functional categories and subcategories and each is identified as either required or desired, described more fully in Section 2 of this document.

1.2 Project Purpose and Scope

The purpose of the project is to deploy operational tools that will enable the City to make informed decisions about operational strategies to improve their traffic signals and the operations of the project corridors. The tools that will be deployed as part of this project include an ATSPM system as well as some level of detection necessary for each performance measure.

The City of San Rafael is proposing to procure a commercially-available, off-the-shelf ATSPM system. Configuration of up to 54 signalized intersections within the City's downtown grid will allow the City to collect high-resolution data and proactively manage the traffic signal network. The final intersection count may be reduced to fit within the project budget.

A map of the project limits is shown in Figure 1 and a listing of the project intersections is shown in Table 1.

Figure 1: **System Project Limits**

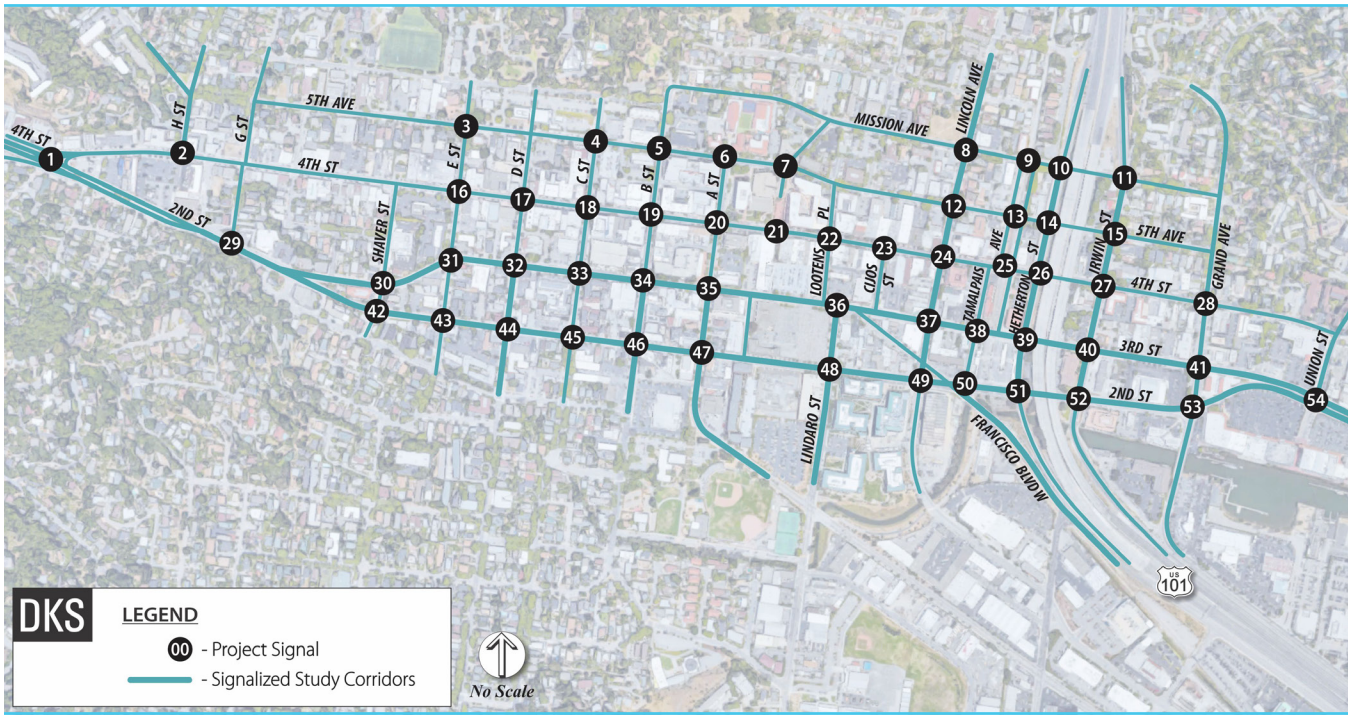

Table 1: **Project Intersections**

INT. NO.	INTERSECTION
1	2nd Street & 4th Street
2	4th Street & H Street
3	5th Avenue & E Street
4	5th Avenue & C Street
5	5th Avenue & B Street
6	5th Avenue & A Street
7	5th Avenue & Court Street
8	Mission Avenue & Lincoln Avenue
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23	4th Street & Cijos Street
24	4th Street & Lincoln Avenue
25	4th Street & Tamalpais Avenue
26	4th Street & Hetherton Street
27	4th Street & Irwin Street

INT. NO.	INTERSECTION
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29	2nd Street & G Street
30	3rd Street & Shaver Street
31	3rd Street & E Street
32	3rd Street & D Street
33	3rd Street & C Street
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41	3rd Street & Grand Avenue
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46	2nd Street & B Street
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49	2nd Street & Lincoln Avenue
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53	2nd Street & Grand Avenue
54	3rd Street & Union Street

2 Requirements

The requirements shown in Appendix A are divided into categories and subcategories as defined below. The requirements are listed as required or desired and reflect the needs and objectives determined by San Rafael stakeholders.

SIGNAL PERFORMANCE MEASURES:
REQUIREMENTS FOR THE SIGNAL PERFORMANCE MEASURES (SPM) TO BE PROVIDED BY THE ATSPM SYSTEM

1. General SPM Requirements
2. Reports Requirements
3. Alerts/Alarms Requirements
4. Mapping Requirements

SYSTEM SUPPORT AND MANAGEMENT:
REQUIREMENTS INVOLVING BASIC DATA EXCHANGE AND ARCHITECTURE OF THE ATSPM SYSTEM

5. General Access Requirements
6. General Data Requirements
7. Vendor Support Requirements
8. Security Requirements

To provide traceability, each requirement includes a reference to associated user needs and key performance measures. The full list of user needs and key performance measures are included in Tables 2 through 4.

- **Table 2** identifies the user need categories and abbreviations.
- **Table 3** provides the complete list of user needs and reference numbers.
- **Table 4** identifies the key ATSPM system performance measures and whether they are required or desired.

Table 2: **User Need Categories and Abbreviations**

CATEGORY	ABBREVIATION	DESCRIPTION
Operations	NOP	User needs related to the operations of the traffic signal
Planning	NPL	User needs related to collecting and tracking data and trends
Reporting and Documenting	NRD	User needs related to the performance measures reports
Network and Access	NAR	User needs related to the system network and access
Maintenance	NMT	User needs related to system maintenance and support
Other	NOT	User needs not included in the other categories

Table 3: **ATSPM System User Needs**

NUMBER	USER NEED
NOP-1	The user needs to know when a phase is not long enough to serve the demand on a consistent basis (i.e., phase failure).
NOP-2	The user needs to know when a phase gaps out, maxes out or is forced off.
NOP-3	The user needs to know where there are high delays on specific approaches.
NOP-4	The user needs to know how efficient the progression is along a corridor.
NOP-5	The user needs to know how railroad preemption impacts the nearby traffic signals and its system-wide impacts.

Table 3: **ATSPM System User Needs, *Continued***

NUMBER	USER NEED
NOP-6	The user needs to know when the queue cutter signals are enabled and disabled.
NOP-7	The user needs to know when and how long the No Right Turn blank out signs are active.
NOP-8	The user needs to know when large queues form at specific locations.
NOP-9	The user needs to know when each coordinated timing plan was active
NOP-10	The user needs to know when a traffic signal is in transition.
NOP-11	The user needs to know the length of each phase and cycle.
NOP-12	The user needs to know when the pedestrian push buttons are activated
NOP-13	The user needs to know when communications to the traffic signals fail.
NOP-14	The user needs to know when the intersections go into Flash mode.
NOP-15	The user needs to collect travel time along select arterials.
NPL-1	The user needs to collect, report and track vehicle volume data.
NPL-2	The user needs to collect, report and track bicycle volume data.
NPL-3	The user needs to collect, report and track number of railroad preemptions.
NPL-4	The user needs to collect, report and track length of railroad preemptions.
NPL-5	The user needs to collect, report and track pedestrian volume data.

Table 3: **ATSPM System User Needs, *Continued***

NUMBER	USER NEED
NRD-1	The user needs to retrieve data from the local controllers and create the performance measure reports.
NRD-2	The user needs reports that are customizable by timeframe and data interval.
NRD-3	The user needs to produce both automated reports and reports based on a specific query.
NRD-4	The user needs to access near real-time logs (within five minutes) to produce reports.
NRD-5	The user needs to produce reports that are high-level summaries for decision makers and detailed for use in operations and troubleshooting.
NRD-6	The user needs to store the logs, alarms, and reports for a set amount of time where they are easily accessible.
NRD-7	The user needs to produce performance measures based on the Purdue Data Set and show them graphically.
NRD-8	The user needs a dashboard that is configurable for each user and each of the performance measures
NRD-9	The system needs to send alerts based on user defined triggers (using high-resolution data)
NRD-10	The system needs to produce reports that compare current operations to past performance for a given intersection.
NAR-1	The user needs to access the system from the City network and remotely via VPN.
NAR-2	The system needs to fully function between network security devices (i.e., fire walls).
NAR-3	The user needs access to full resolution data for a period of three years (fully query able). After three years, data may be compressed and archived to be stored indefinitely.
NAR-4	The user needs to receive alerts based on triggers via email or texts.

Table 3: **ATSPM System User Needs, *Continued***

NUMBER	USER NEED
NAR-5	The user needs to collect data and produce reports on any City signal connected to the system.
NAR-6	Multiple users need to access the system at the same time.
NAR-7	The system needs to access the system via a smartphone.
NMT-1	The user needs vendor support for training and maintenance.
NMT-2	The user needs user manuals for system set-up, configuration, operations and maintenance.
NMT-3	The user needs on-call support for maintenance and troubleshooting issues.
NMT-4	The user needs to be notified of software revisions when they become available.
NMT-5	The user needs to know when detectors fail.
NOT-1	The system needs to be compatible with Econolite Cobalt and ASC3 traffic signal controllers.
NOT-2	If the system fails, the existing Centracs central traffic signal systems and local controllers shall not be negatively impacted.
NOT-3	The system needs to make recommendations for signal timing parameter changes.

Table 4: **Key ATSPM System Performance Measures**

CATEGORY	PERFORMANCE MEASURE	REQUIRED	DESIRED
Intersection Performance	Approach Delay	●	
	Split Monitor	●	
	Purdue Phase Termination	●	
	Purdue Split Failure	●	
	Detector Health		●
	Yellow and Red Actuations	●	
	Coordination Mode Status		●
Corridor Performance	Speed		●
	Arrivals on Green (Purdue Coordination Diagram)		●
	Arrivals on Red		●
	Travel Time		●
Multimodal	Pedestrian Delay	●	
	Pedestrian Volume		●
	Bicycle Volume		●
Preemption	Number of Preemptions	●	
	Length of Preemptions	●	
Planning	Vehicle Approach Volume	●	
	Vehicle Turn Movement Counts		●

Appendix A – System Requirements

Req. Number	Requirement Text	Required	Desired	User Need Trace
1	The system shall use the high resolution (tenth of second) data enumerations detailed in Tables 4.1 to 4.9 in the document "Performance Measures for Traffic Signal Systems, An Outcome-Oriented Approach" 2014	✓		Multiple
1.1	The system shall be compatible with high resolution data enumerations from NTCIP compliant controllers, including Econolite Cobalt and ASC3 traffic signal controllers	✓		NOT-1
2	The system shall provide intersection-level metrics for locations equipped with detection as listed below:			
2.1	Delay per vehicle approach/phase	✓		NOP-3, Table 4 Key Performance Measures
2.2	Approach speed		✓	NOP-15, Table 4 Key Performance Measures
2.3	Volume per approach/phase	✓		NRD-7, NPL-1, Table 4 Key Performance Measures
2.4	Number of arrivals on red		✓	NRD-7, NOP-4, Table 4 Key Performance Measures
2.5	Percent arrival on red		✓	NRD-7, NOP-4, Table 4 Key Performance Measures
2.6	Number of arrivals on green		✓	NRD-7, NOP-4, Table 4 Key Performance Measures
2.7	Percent arrival on green (Purdue coordination diagram)		✓	NRD-7, NOP-4, Table 4 Key Performance Measures
2.8	Platoon ratio		✓	NRD-7, NOP-4, Table 4 Key Performance Measures
2.9	Bicycle volume per approach/phase		✓	NPL-2, Table 4 Key Performance Measures
2.10	Pedestrian actuations per phase	✓		NRD-7, NOP-12, NPL-5, Table 4 Key Performance Measures
2.11	Pedestrian delay per phase	✓		NRD-7, Table 4 Key Performance Measures
2.12	Number of railroad preemption events per approach	✓		NRD-7, NPL-3, NOP-5, Table 4 Key Performance Measures
2.13	Duration of railroad preemption events per approach	✓		NRD-7, NPL-4, NOP-5, Table 4 Key Performance Measures
2.14	Queue cutter signal activations	✓		NOP-6
2.15	"No right turn" blank-out sign activations	✓		NOP-7
2.16	Phase split monitor	✓		NRD-7, NOP-1, NOP-11, Table 4 Key Performance Measures
2.17	Reason for phase termination (gap out, max out, force off)	✓		NRD-7, NOP-2, NOP-12, Table 4 Key Performance Measures
2.18	Detector red occupancy ratio during the first five seconds of red for that phase (ROR5)		✓	NRD-7, NOP-1, Table 4 Key Performance Measures
2.19	Coordination mode status/summary	✓		NOP-5, NOP-9, Table 4 Key Performance Measures
2.22	Queue length (based on detector input)	✓		NOP-8
2.23	Yellow and Red Actuations		✓	NRD-7, Table 4 Key Performance Measures
2.24	Vehicle turn movement counts		✓	NRD-7, NPL-1, Table 4 Key Performance Measures
2.25	Pedestrian volume		✓	NPL-5, Table 4 Key Performance Measures
2.26	The system shall provide corridor-level metrics for locations equipped with travel time detection as listed below:			
2.26.1	Speed		✓	Table 4 Key Performance Measures
2.26.2	Travel Time		✓	NOP-15, Table 4 Key Performance Measures
3	The system reports shall be created and/or exported to the following formats:			
3.1	Graphs	✓		NRD-2, NRD-5, NRD-7, NAR-5
3.2	Tables	✓		NRD-2, NRD-5, NRD-7, NAR-5
3.3	CSV	✓		NRD-2, NRD-5, NRD-7, NAR-5
3.4	XLS	✓		NRD-2, NRD-5, NRD-7, NAR-5
3.5	PDF	✓		NRD-2, NRD-5, NRD-7, NAR-5
3.6	MS Word	✓		NRD-2, NRD-5, NRD-7, NAR-5
4	The system shall provide real time (within five minutes) reports.	✓		NRD-4
5	The system shall provide historical reports.	✓		NRD-5, NRD-10
6	The system shall provide reports based on cycle by cycle data	✓		NRD-2, NRD-5
7	The system shall provide reports based on user-defined queries for performance measure and time period	✓		NRD-2, NRD-3, NRD-4, NRD-5, NRD-10
8	The system shall provide reports that compare current data to historical data for user-specified metrics and time periods	✓		NRD-2, NRD-8, NRD-10
9	The system shall provide reports on average arrivals on green per intersection in network		✓	NOP-4, NRD-5
9.1	The system shall provide reports on corridor average arrivals on green		✓	NOP-4, NRD-5
10	The system shall provide reports on average arrivals on red per intersection in network		✓	NOP-4, NRD-5
10.1	The system shall provide reports on corridor average arrivals on red		✓	NOP-4, NRD-5
11	The system shall provide reports on average delay per intersection.	✓		NOP-3, NOP-5, NRD-5
12	The system shall provide reports on split failure counts per interection in network	✓		NOP-1, NOP-2, NRD-5
13	The system shall provide automated reports for user-defined measures	✓		NRD-3, NRD-5
14	The system shall provide automated reports for user-defined time period	✓		NRD-3, NRD-5
15	The system shall recommend changes to intersection phase split times based on operational thresholds		✓	NOT-3
16	The system shall recommend changes to intersection offsets based on operational thresholds		✓	NOT-3

Req. Number	Requirement Text	Required	Desired	User Need Trace
17	The system shall generate point-to-point travel time calculations (within five minutes of capture) between intersections equipped with necessary detection		✓	NOP-15
18	The system shall compare current travel time to historical travel time for any user-selected time periods throughout the three year data set		✓	NOP-15, NRD-10
19	The system shall provide reports on historical and real-time alerts with alert time, alert notification, and alert resolution.		✓	NRD-6
20	The system shall highlight individual intersections that have experienced communication failures over a user-specified time period.	✓		NRD-5, NRD-6
21	The system shall send real-time and summary alerts via text and email based on the following triggers: ("User Defined" means, at a minimum, per time period, per approach, per frequency)			
21.1	No communications to controller	✓		NOP-13, NRD-9, NAR-4
21.2	When controller is in Flash mode	✓		NOP-14, NRD-9, NAR-4
21.3	Detector actuations (user-defined)	✓		NRD-9, NAR-4, NMT-5
21.4	Phase max out (user-defined)	✓		NOP-1, NOP-2, NRD-9, NAR-4
21.5	Approach delay (user-defined)	✓		NOP-3, NRD-9, NAR-4
21.6	Queue length (based on detector input)		✓	NOP-8, NRD-9, NAR-4
21.7	Daily summary of all alerts in last 24 hours		✓	NRD-3, NRD-9, NAR-4
21.8	Any user-configurable combination of inputs and outputs		✓	NOP-6, NOP-7, NRD-9, NAR-4
22	The system shall report the status of the communications link	✓		NOP-13, NRD-9, NAR-4
23	The system shall report the health of the detectors based on:			
23.1	User-defined activity (i.e., too many actuations)	✓		NRD-9, NMT-5, Table 4 Key Performance Measures
23.2	User-defined inactivity (i.e., too few actuations)	✓		NRD-9, NMT-5, Table 4 Key Performance Measures
24	The system user interface shall consist of a front page dashboard customizable by user		✓	NRD-8
25	The system user interface shall provide a dashboard component showing user-defined measures, alerts, and summaries		✓	NRD-8
26	The system shall allow multiple saved views per user	✓		NRD-8
27	The system shall provide a map-based view and interface	✓		NRD-8
28	The system shall allow the user to zoom and pan the map view	✓		NRD-8
29	The system shall provide ability to search for specific intersection on map.	✓		NRD-8, NAR-5
30	The system shall provide ability to search for specific intersection from list.	✓		NRD-8, NAR-5
31	The system shall provide a minimum of 5 concurrent logins for authenticated users.	✓		NAR-6
32	The system shall be fully accessible via the following:			
32.1	Windows-based desktop or laptop	✓		NAR-1, NAR-2, NAR-5
32.2	Mac-based desktop or laptop	✓		NAR-1, NAR-2, NAR-5
32.3	Tablet using Apple iOS, Google Android or Windows for mobile devices	✓		NAR-1, NAR-2, NAR-5, NAR-7
32.4	Mobile phone using Apple iOS, Google Android or Windows for mobile devices	✓		NAR-1, NAR-2, NAR-5, NAR-7
32.5	Chrome web browser	✓		NAR-1, NAR-2, NAR-5
32.6	Internet Exlporer/Edge web browser	✓		NAR-1, NAR-2, NAR-5
32.7	Safari web browser	✓		NAR-1, NAR-2, NAR-5
32.8	VPN	✓		NAR-1
33	The system shall not negatively impact the operations of the existing Centracs ATMS system, in the event of a failure.	✓		NOT-2
34	The system shall accommodate a minimum of 100 intersections.	✓		NAR-5
35	The system shall support access of data via a modern REST application programmable interface (API) in JSON or XML format	✓		NAR-2, NAR-3
36	The system shall provide access to high resolution traffic data for a period of one year.	✓		NAR-3
37	The system shall provide access to logs, alarms and reports for a period of one year.	✓		NAR-3
38	The system shall archive all traffic data after one year.	✓		NAR-3
43	The system shall work within the City's firewall and abide by cyber security requirements	✓		NAR-2
44	The system shall support authentication of individual users via user names and passwords	✓		NAR-2
45	The system shall provide varied levels of data access and analytic functionality based on user type	✓		NAR-2

APPENDIX C – Verification Plan

INNOVATIVE DEPLOYMENT TO ENHANCE ARTERIALS CATEGORY 1

City of San Rafael

Automated Traffic Signal Performance Measures

Verification Plan

JULY 2019

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Figures

1 Scope

1.1 Document Purpose and Scope

The purpose of this document is to identify the verification activity needed to validate a new Automated Traffic Signal Performance Measures (ATSPM) for the City of San Rafael and ensure that the system meets the identified system requirements.

1.2 Project Purpose and Scope

The purpose of the project is to deploy operational tools that will enable the City to make informed decisions about operational strategies to improve their traffic signals and the operations of the project corridors, as well as provide the City with necessary data to conduct post-performance monitoring. The tools that will be deployed as part of this project include an ATSPM system, as well as any vehicle and/or pedestrian detection necessary for each performance measure.

The City of San Rafael is proposing to procure a commercially-available, off-the-shelf ATSPM system. Configuration of up to 54 signalized intersections within the City's downtown grid will allow the City to collect high-resolution data and proactively manage the traffic signal network. The final intersection count may be reduced to fit within the project budget.

A listing of the project intersections is shown in Table 1 and a map of the project limits is shown in Figure 1.

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53	2nd Street & Grand Avenue
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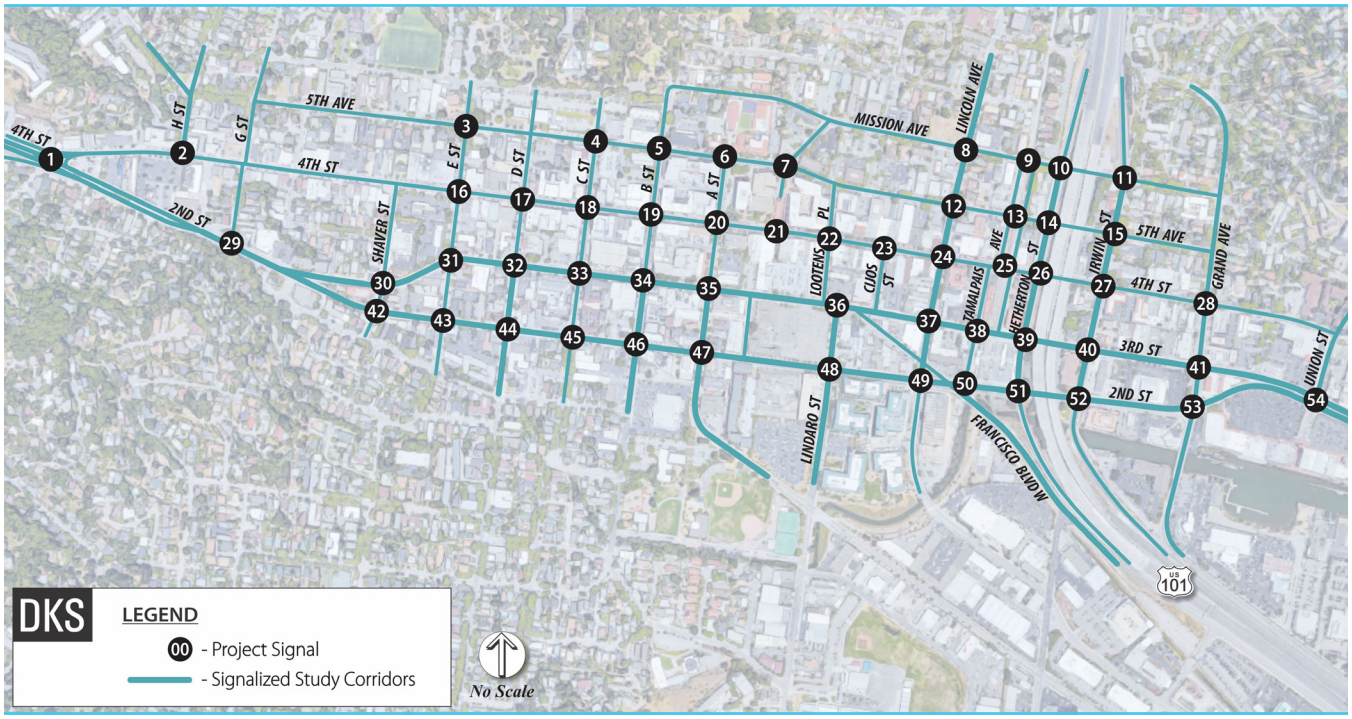
Figure 1: **System Project Limits**



2 Referenced Documents

- **MTC IDEA Category 1 City of San Rafael Automated Traffic Signal Performance Measures (ATSPM) Final Needs Assessment**, DKS Associates, December 2018.
- **MTC IDEA Category 1 City of San Rafael Automated Traffic Signal Performance Measures (ATSPM) Final Concept of Operations,** DKS Associates, June 2019.
- **MTC IDEA Category 1 City of San Rafael Automated Traffic Signal Performance Measures (ATSPM) Revised Draft System Requirements**, DKS Associates, June 2019.
- **Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems, U.S. Department of Transportation**, Federal Highway Administration, FHWA-HOP-11-027, August 2012.

3 Conducting Verification

The verification of the ATSPM system will be conducted by the selected vendor, in the presence of the City of San Rafael staff, MTC staff, and the Systems Engineer. DKS Associates, the systems engineering consultant to MTC and the City for the IDEA grant project, shall provide the Systems Engineer services. Oversight of the verification process and system acceptance will be provided by the Systems Engineer.

The vendor shall submit verification procedures prior to conducting testing in accordance with the contract requirements. All mandatory requirements must be verified during testing. Any desired requirements that are included in the vendor's proposal must be tested and verified. The City of San Rafael shall witness all testing. Any acceptance must be agreed to by City staff. City staff may take recommendations on acceptance or failure of testing from MTC staff or the Systems Engineer.

The vendor shall provide all materials and equipment for testing. If City staff is required to provide any hardware, networking access, or other equipment deemed necessary, staff shall be notified at a minimum of two weeks in advance of testing. The date and time of testing shall be coordinated so that all interested parties can attend.

All testing for the ATSPM system shall be conducted on a workstation at the City's Traffic Management Center (TMC) located in the Public Works building and in the field. The intersections used for testing will be approved by City staff in advance of testing. When necessary, additional personnel may be required in the field to establish certain testing conditions, such as initiating communication or power failures or to form queues. Any failure scenarios must be conducted in a controlled environment under direction of City staff.

Bench testing will be conducted at the City's TMC. Locations and primary contacts are listed below:

RAFAT RAIE, DEPUTY DIRECTOR
OF PUBLIC WORKS
CITY OF SAN RAFAEL
PUBLIC WORKS DEPARTMENT
111 MORPHEW STREET
SAN RAFAEL, CALIFORNIA 94901
PH. 415.485.3473
RAFAT.RAIE@CITYOFSANRAFAEL.ORG

Additional verification testing will take place in the field for each project location with field-deployed hardware and software. The verification table (Appendix A) indicates where the test should be conducted. Testing will involve the following equipment:

- Econolite ACS/3 and Cobalt ATC traffic signal controllers operating Centracs central signal system software (in field and in a testing environment)
- Workstations within the Traffic Management Center
- Tablet devices with Internet access

The vendor shall document the results of the system verification testing using the testing requirements provided in Appendix A. In the event that a requirement is not able to be tested successfully, the vendor shall document the failure, the cause (if known), and the procedures necessary to repair the failure. Depending on the cause or nature of the failure, and under the direction of City staff, either a portion of the test procedures or the entire test plan will be conducted again when the failure is remedied. The extent of retesting will be determined by City staff in consultation with MTC and the Systems Engineer. Final documentation of the failures, the resolution, and the results of the retest are required.

A 30-day burn-in period is required for all hardware and software prior to conducting the verification tests to ensure that data collection, analysis, storage, and retrieval are all performing as expected.

A record shall be maintained of each verification test, the outcome of the verification recorded, and the record signed by the vendor and City staff.

The outcome of each verification test shall be recorded as one of the following:

- Meets Requirements
- Partially Meets Requirements, with a statement of acceptable supplementary testing
- Does Not Meet Requirements

4 Verification Identification

This section identifies specific verification cases to be performed. A verification case is a logical grouping of functions and performance criteria that are to be verified together. Each case should contain the following:

- Test name and reference number
- Requirements to be verified
- Test circumstances – identification of necessary hardware, software, and intersection(s)
- Test script – steps required to conduct the test
- Pass/Fail criteria – data to be recorded or noted during verification, such as expected results
- Comments on how requirements are met, and proposed action if only partially met or not met
- Observing party sign off

The following test cases have been identified to correspond with the primary verification methods as outlined in the verification and test case matrix in Appendix A. The detailed test scripts, circumstances, and instructions shall be developed by the ATSPM vendor based on the matrix. The test procedures for acceptance testing will be submitted in accordance with the schedule provided by the vendor during procurement and must be consistent with this Verification Plan.

TEST CASE 1: PRODUCT SUBMITTAL REVIEW

The ATSPM vendor shall submit product specifications, cut sheets, and/or engineering drawings to the City for requirements verification and acceptance.

TEST CASE 2: PRODUCT DEMONSTRATION

The ATSPM vendor shall develop detailed testing scripts to demonstrate the identified system requirements. After the vendor has installed and deployed the system, a series of detailed demonstration tests will be conducted utilizing City traffic signal data. City staff will observe the demonstration.

TEST CASE 3: FIELD OBSERVATIONS

The ATSPM vendor shall conduct a visual inspection of system performance and/or functionality in the field. This visual confirmation will document how the system satisfies requirements associated with field-observed operations and/or functions.

TEST CASE 4: CONTRACT DOCUMENTATION

The ATSPM vendor shall execute contract documentation that addresses the identified requirements.

Appendix A – ATSPM System Verification

MTC IDEA Category 1
City of San Rafael ATSPM

Test Case Descriptions	
Test Case 1:	*Product submittal review*
Test Case 2:	*Product demonstration*
Test Case 3:	*Field observations*
Test Case 4:	*Contract documentation*

Appendix A
ATSPM System Verification

Requirement No.	Requirement Text	Required (R) / Desired (D)	Test Case	Verification Method	Test Location	Met	Partially Met	Not Met	Description of how Requirement is Met, Partially Met, or Not Met
Signal Performance Measures									
General SPM									
1	The system shall use the high resolution (tenth of second) data enumerations detailed in Tables 4.1 to 4.9 in the document "Performance Measures for Traffic Signal Systems, An Outcome-Oriented Approach" 2014	R	2	Demonstration of software	Bench				
1.1	The system shall be compatible with high resolution data enumerations from the Econolite Cobalt and ASC3 traffic signal controllers	R	2	Demonstration of software	Bench				
2	The system shall provide intersection-level metrics for locations equipped with detection as listed below:			N/A					
2.1	Delay per vehicle approach/phase	R	2	Demonstration of software	Bench				
2.2	Approach speed	D	2	Demonstration of software	Bench				
2.3	Volume per approach/phase	R	2	Demonstration of software	Bench				
2.4	Number of arrivals on red	D	2	Demonstration of software	Bench				
2.5	Percent arrival on red	D	2	Demonstration of software	Bench				
2.6	Number of arrivals on green	D	2	Demonstration of software	Bench				
2.7	Percent arrival on green (Purdue coordination diagram)	D	2	Demonstration of software	Bench				
2.8	Platoon ratio	D	2	Demonstration of software	Bench				
2.9	Bicycle volume per approach/phase	D	2	Demonstration of software	Bench				
2.10	Pedestrian actuations per phase	R	2	Demonstration of software	Bench				
2.11	Pedestrian delay per phase	R	2	Demonstration of software	Bench				
2.12	Number of railroad preemption events per approach	R	2	Demonstration of software	Bench				
2.13	Duration of railroad preemption events per approach	R	2	Demonstration of software	Bench				
2.14	Queue cutter signal activations	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
2.15	"No right turn" blank-out sign activations	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
2.16	Phase split monitor	R	2	Demonstration of software	Bench				
2.17	Reason for phase termination (gap out, max out, force off)	R	2	Demonstration of software	Bench				
2.18	Detector red occupancy ratio during the first five seconds of red for that phase (ROR5)	D	2	Demonstration of software	Bench				
2.19	Coordination mode status/summary	R	2	Demonstration of software	Bench				
2.22	Queue length (based on detector input)	R	2	Demonstration of software	Bench				
2.23	Yellow and red actuations	D	2	Demonstration of software	Bench				
2.24	Vehicle turn movement counts	D	2	Demonstration of software	Bench				
2.25	Pedestrian volume	D	2	Demonstration of software	Bench				
2.26	The system shall provide corridor-level metrics for locations equipped with travel time detection as listed below:			N/A					
2.26.1	Speed	D	2	Demonstration of software	Bench				
2.26.2	Travel Time	D	2	Demonstration of software	Bench				
Reports									
3	The system reports shall be in the following formats:			N/A					
3.1	Graphs	R	2	Demonstration of software	Bench				
3.2	Tables	R	2	Demonstration of software	Bench				
3.3	CSV	R	2	Demonstration of software	Bench				
3.4	XLS	R	2	Demonstration of software	Bench				
3.5	PDF	R	2	Demonstration of software	Bench				
3.6	MS Word	R	2	Demonstration of software	Bench				
4	The system shall provide real time (within five minutes) reports.	R	2	Demonstration of software	Bench				
5	The system shall provide historical reports.	R	2	Demonstration of software	Bench				
6	The system shall provide reports based on cycle by cycle data	R	2	Demonstration of software	Bench				
7	The system shall provide reports based on user-defined queries for performance measure and time period	R	2	Demonstration of software	Bench				
8	The system shall provide reports that compare current data to historical data for user-specified metrics and time periods	R	2	Demonstration of software	Bench				
9	The system shall provide reports on average arrivals on green per intersection in network	D	2	Demonstration of software	Bench				
9.1	The system shall provide reports on corridor average arrivals on green	D	2	Demonstration of software	Bench				
10	The system shall provide reports on average arrivals on red per intersection in network	D	2	Demonstration of software	Bench				
10.1	The system shall provide reports on corridor average arrivals on red	D	2	Demonstration of software	Bench				
11	The system shall provide reports on average delay per intersection.	R	2	Demonstration of software	Bench				
12	The system shall provide reports on split failure counts per interection in network	R	2	Demonstration of software	Bench				
13	The system shall provide automated reports for user-defined measures	R	2	Demonstration of software	Bench				
14	The system shall provide automated reports for user-defined time period	R	2	Demonstration of software	Bench				
15	The system shall recommend changes to intersection phase split times based on operational thresholds	D	2	Demonstration of software	Bench				
16	The system shall recommend changes to intersection offsets based on operational thresholds	D	2	Demonstration of software	Bench				
17	The system shall generate point-to-point travel time calculations (within five minutes of capture) between intersections equipped with necessary detection	D	2	Demonstration of software	Bench				

18	The system shall compare current travel time to historical travel time for any user-selected time periods throughout the three year data set	D	2	Demonstration of software	Bench				
19	The system shall provide reports on historical and real-time alerts with alert time, alert notification, and alert resolution.	D	2	Demonstration of software	Bench				
20	The system shall highlight individual intersections that have experienced communication failures over a user-specified time period.	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
Alerts/Alarms									
21	The system shall send real-time and summary alerts via text and email based on the following triggers:			N/A					
21.1	No communications to controller	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
21.2	When controller is in Flash mode	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
21.3	Detector actuations (user-defined)	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
21.4	Phase max out (user-defined)	R	2, 3	Demonstration of software / visual inspection	Field/Bench				
21.5	Approach delay (user-defined)	R	2	Demonstration of software	Bench				
21.6	Queue length (based on detector input)	D	2, 3	Demonstration of software / visual inspection	Field/Bench				
21.7	Daily summary of all alerts in last 24 hours	D	2	Demonstration of software	Bench				
21.8	Any user-configurable combination of inputs and outputs	D	2	Demonstration of software	Bench				
22	The system shall report the status of the communications link	R	2	Demonstration of software	Bench				
23	The system shall report the health of the detectors based on:			N/A					
23.1	User-defined activity (too many actuations)	R	2	Demonstration of software	Bench				
23.2	User-defined inactivity (too few actuations)	R	2	Demonstration of software	Bench				
Mapping									
24	The system user interface shall consist of a front page dashboard customizable by user	D	2	Demonstration of software	Bench				
25	The system user interface shall provide a dashboard component showing user-defined measures, alerts, and summaries	D	2	Demonstration of software	Bench				
26	The system shall allow multiple saved views per user	R	2	Demonstration of software	Bench				
27	The system shall provide a map-based view and interface	R	2	Demonstration of software	Bench				
28	The system shall allow the user to zoom and pan the map view	R	2	Demonstration of software	Bench				
29	The system shall provide ability to search for specific intersection on map.	R	2	Demonstration of software	Bench				
30	The system shall provide ability to search for specific intersection from list.	R	2	Demonstration of software	Bench				
System Support and Management									
General Access									
31	The system shall provide a minimum of 20 concurrent logins for authenticated users.	R	2	Demonstration of software	Bench				
32	The system shall be fully accessible via the following:			N/A					
32.1	Windows-based desktop or laptop	R	2	Demonstration of software	Bench				
32.2	Mac-based desktop or laptop	R	2	Demonstration of software	Bench				
32.3	Tablet using Apple iOS, Google Android or Windows for mobile devices	R	2	Demonstration of software	Bench				
32.4	Mobile phone using Apple iOS, Google Android or Windows for mobile devices	R	2	Demonstration of software	Bench				
32.5	Chrome web browser	R	2	Demonstration of software	Bench				
32.6	Internet Explorer/Edge web browser	R	2	Demonstration of software	Bench				
32.7	Safari web browser	R	2	Demonstration of software	Bench				
32.8	VPN	R	2	Demonstration of software	Bench				
33	The system shall not interfere with existing Centracs ATMS system.	R	2, 3	Demonstration of software / visual inspection	Field (KITS)/Bench				
34	The system shall accommodate a minimum of 1000 intersections.	R	1	Review product cut sheet/shop drawing	Bench				
35	The system shall support access of data via a modern REST application programmable interface (API) in JSON or XML format	R	2	Demonstration of software	Bench				
General Data									
36	The system shall provide access to high resolution traffic data for a period of three years.	R	2, 4	Demonstration of software / Contract requirement	Bench				
37	The system shall provide access to logs, alarms and reports for a period of three years.	R	2, 4	Demonstration of software / Contract requirement	Bench				
38	The system shall archive all traffic data after three years.	R	2, 4	Demonstration of software / Contract requirement	Bench				
Vendor Support									
39	The vendor shall provide a series of two training sessions (at turn-on and after six months)	R	4	Contract documentation (Staff training)	Bench				
40	The vendor shall provide user manuals for configuration, operation and maintenance.	R	4	Contract documentation	Bench				
41	The vendor shall provide on-call technical support/maintenance for three years	R	4	Contract documentation	Bench				
42	The vendor shall provide software updates for the life of the contract.	R	4	Contract documentation	Bench				
Security									
43	The system shall work within the City's firewall and abide by cyber security requirements	R	2, 4	Demonstration of software / Contract requirement	Bench				
44	The system shall support authentication of individual users via user names and passwords	R	2	Demonstration of software	Bench				
45	The system shall provide varied levels of data access and analytic functionality based on user type	R	2	Demonstration of software	Bench				

APPENDIX D – Infrastructure Inventory

SigNum	Location	ContlType	Cabinet Type	Battery Back up	Ped Head	Audible Ped Head	Ped Count Down	Blank Out Turn Sign	Detection	InterType	Identify Intersection Improvement/Upgrade Needs (Item & Quantity)
1	2nd & 4th (2 controllers)	ASC2/S	M / M		yes		TRUE		camera	Radio	
2	4th & H	ASC/2S	M		yes		TRUE		None	Radio	
3	5th & E	ASC/2S	O		yes		TRUE		loops	Radio	
4	5th & C	CBD6000	G		yes		TRUE		None	Radio	
5	5th & B	CBD6000	G		yes		TRUE		None	Radio	
6	5th & A	CBD6000	G		yes		TRUE		None	Radio	
7	5th & COURT	CBD6000	G		yes		TRUE		loops	Radio	
8	MISSION & LINCOLN	COBALT	O	Yes	yes		TRUE		EB, LT pocket loops	Fiber optics	
9	Mission/Tamalpais	COBALT	O	yes	yes		TRUE	Yes	camera	Fiber optics	
10	MISSION & HETHERTON	COBALT	O	yes	yes		TRUE	Yes	None	Fiber optics	
11	MISSION & IRWIN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
12	5th & LINCOLN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
13	5th & Tamalpais	COBALT	O	yes	yes		TRUE	Yes	camera, loops	Fiber optics	
14	5th & HETHERTON	COBALT	O	Yes	yes	YES	TRUE	Yes	None	Fiber optics	
15	5th & IRWIN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
16	4th & E	CBD6000	G		yes		TRUE		None	Radio	
17	4th & D	CBD6000	G		yes		TRUE		None	Radio	
18	4th & C	CBD6000	G		yes		TRUE		None	Radio	
19	4th & B	CBD6000	G		yes		TRUE		None	Radio	
20	4th & A	CBD6000	G		yes		TRUE		None	Radio	
21	4th & COURT	CBD6000	G		yes		TRUE		None	Radio	
22	4th & LOOTENS	CBD6000	G		yes		TRUE		None	Radio	
23	4th & CIJOS	CBD6000	G		yes		TRUE		None	Radio	
24	4th & LINCOLN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
25	4th & Tamalpais	COBALT	O	Yes	YES		TRUE	Yes	camera, loops	Fiber optics	
26	4th & HETHERTON	COBALT	O	Yes	yes	YES	TRUE	Yes	None	Fiber optics	
27	4th & IRWIN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
28	4th & GRAND	COBALT	O				FALSE		None	Hardwire	
29	2nd & G	ASC3	P		yes		TRUE		camera	Hardwire/ATT	
30	3rd & SHAVER	ASC/3	O		yes		TRUE		None	Hardwire	
31	3rd & E	COBALT	O		yes		TRUE		None	Hardwire	
32	3rd & D	ASC/3	O				FALSE		None	Hardwire	
33	3rd & C	ASC/3	O		yes		TRUE		None	Hardwire	
34	3rd & B	ASC/3	O				FALSE		None	Hardwire	
35	3rd & A	COBALT	O		yes		TRUE		None	Hardwire	
36	3rd & LINDARO	ASC/3	O		yes		TRUE		None	Hardwire	
37	3rd & LINCOLN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	

38	3rd & TAMALPAIS	COBALT	O	yes	yes		TRUE		None	Fiber optics	
39	3rd & HETHERTON	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
40	3rd & IRWIN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
41	3rd & GRAND	COBALT	O		yes (w-leg only)		FALSE		None	Hardwire	
42	2nd & SHAVER	ASC3	O		yes		TRUE		None	Hardwire	
43	2nd & E	COBALT	O		yes		TRUE		None	Hardwire	
44	2nd & D	COBALT	O		yes		TRUE		None	Hardwire	
45	2nd & C	ASC/3	O		yes		TRUE		None	Hardwire	
46	2nd & B	COBALT	O		yes		TRUE		None	Hardwire	
47	2nd & A	COBALT	O		yes		TRUE		None	Hardwire	
48	2nd & LINDARO	ASC/3	O		yes		TRUE		None	Hardwire	
49	2nd & LINCOLN	COBALT	O	Yes	yes		FALSE		None	Fiber optics	
50	2nd & TAMALPAIS	COBALT	O	Yes	yes		TRUE		count loops	Fiber optics	
51	2nd & HETHERTON	COBALT	O	Yes	yes (w-leg only)		TRUE		None	Fiber optics	
52	2nd & IRWIN	COBALT	O	Yes	yes		TRUE		None	Fiber optics	
53	2nd & GRAND	COBALT	O				FALSE		None	Hardwire	
54	3rd & UNION	ASC8000	O	YES	yes		TRUE		loops	Hardwire	

APPENDIX E – Cost Proposal Form

COST PROPOSAL FORM

Proposer shall submit proposed costs for the items described in the Scope of Work and System Requirements (Attachment B).

Item	Description	Quantity	Unit	Unit Price	Extended Price
Initial Project					
1	Project Management	1	LS		
2	Furnish ATSPM System	54	EA		
3	Installation, Integration and Deployment	54	EA		
4	System Testing (Verification) and Acceptance	1	LS		
5	Training and Training Documentation	1	LS		
6	ATSPM System Documentation	1	LS		
7	System License, Warranty, and Support (initial 3 years)	1	LS		
				Total Price	
Future Expansion					
	System License, Warranty, and Support (Year 4)	1	LS		
	System License, Warranty, and Support (Year 5)	1	LS		
	System License, Warranty, and Support (Year 6)	1	LS		
	System License, Warranty, and Support (Year 7)	1	LS		
	System License, Warranty, and Support (Year 8)	1	LS		
	System License, Warranty, and Support (Year 9)	1	LS		
	System License, Warranty, and Support (Year 10)	1	LS		