

Integrated Traffic Data Collection and Management Plan

for the Shasta County
South Central Urban
Region (SCUR)



Final Report



Prepared for



Prepared by



Kimley-Horn
and Associates, Inc.

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October 22, 2013

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Executive Summary

Integrated Traffic Data Collection and Management Plan for the Shasta County South Central Urban Region (SCUR)

Project Background and Purpose

The current traffic data collection system for the South Central Urban Region (SCUR) does not provide timely, reliable data that can be useful to the Shasta Regional Transportation Agency (SRTA) for planning activities. With anticipated future growth in the SCUR, the SRTA and Caltrans District 2 envision a data collection system that would provide accurate, timely, reliable, and directly applicable data to make traffic operations and planning activities more efficient. This Implementation Plan:

- details the existing data collection system and processes;
- documents stakeholder needs;
- presents an evaluation of data collection tools and technologies; and
- identifies recommended deployment strategies and approaches.

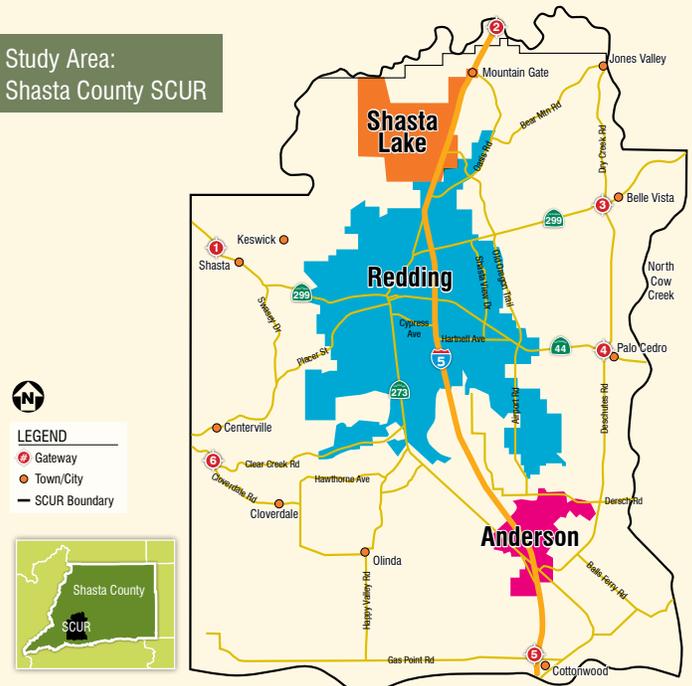
Integrated Traffic Data Collection

An integrated traffic data collection system will provide benefits that can be realized by agencies, as well as the public. For **agencies**, it provides more frequent traffic data to inform transportation planning; faster incident detection, response and clearance; the ability to monitor traffic congestion; enhanced analysis of traffic conditions; and performance monitoring. For the **public**, it means improved safety, greater mobility, and reduced congestion.

An enhanced data collection system is a crucial tool for SRTA to achieve regional transportation goals consistent with the 2010 Regional Transportation Plan (RTP):

- **Improved Safety** – Accurate and reliable traveler information reduces secondary accidents
- **Improved Emergency Response** – Detect and clear incidents quicker
- **Improved Commercial Vehicle Operations** – Through increased availability of commercial vehicle traffic data
- **Increased Traveler Information and Trip Enhancement** – An enhanced system will position the region for future dissemination of traveler information
- **Improved Interagency Communications** – Data is easily shared and accessed by partner agencies

Study Area:
Shasta County SCUR



- **Reduced Congestion** – Traveler information affects driver behavior, which can reduce fuel consumption and vehicle emissions
- **Increased Economic Activity** – Better mobility through the region will improve economic activity

Project Needs and Objectives

Stakeholders identified the following needs of an enhanced data collection system:

- Make volume data available more frequently, at more locations, and at shorter time intervals.
- Implement a tool to provide interregional, intraregional, and local Origin and Destination (O&D) trip information.
- Enhance current processes to better utilize existing traffic data.

Implementation Plan

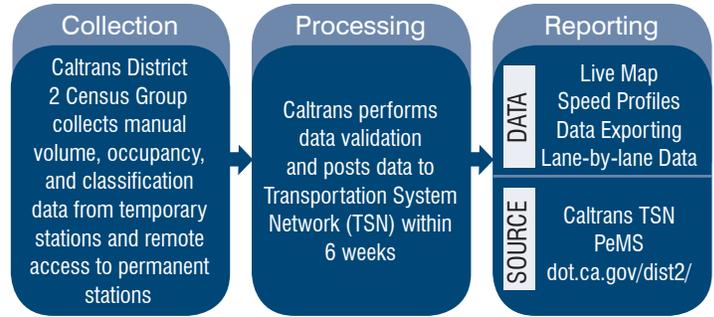
Within the industry, there are many solutions for collecting, processing, reporting, and disseminating traffic data. Data collection varies by the type of information collected, accessible formats, and granularity. Through an evaluation of the current data collection system and consideration of project needs, there are data collection enhancements that need to be implemented within the region to enhance the current Caltrans District 2 Data Collection Process shown to the right.

An alternatives analysis evaluated individual projects based on strategic corridors and feasible technologies that meet the needs of SRTA and Caltrans District 2. The projects are manageable, modular projects that enhance Caltrans' existing data collection infrastructure while considering the priorities and goals of both SRTA and Caltrans District 2. These projects can be deployed as funding becomes available. The table below highlights a \$4.3 million program of preferred alternatives that will meet the data collection needs of SRTA and Caltrans District 2.

The following summary highlights project recommendations to deploy an Integrated Traffic Data Collection System:

- Expand the network of permanent detector count stations through the installation of new detection stations or the upgrading of temporary detection stations at every interchange throughout the SCUR.
- Provide permanent communications and detection equipment to automatically collect data on a more frequent basis.
- Conduct a Bluetooth Pilot Test to evaluate the performance and data samples for origin-destination data.
- If the Caltrans Headquarters' project to automate the interface between the Transportation System Network (TSN) and the Performance Measurement System (PeMS) is not scheduled for the near future, SRTA should work with Caltrans to deploy third party software with data processing and reporting capabilities.
- SRTA and Caltrans District 2 should pursue multiple funding sources for the deployment of the recommended integrated data collection system.

Current Caltrans District 2 Data Collection Process



Project Benefits

By implementing the recommended projects, SRTA, Caltrans and local jurisdictions will receive the following traffic data collection benefits:

- New Origin-Destination (O&D) stations will provide interregional, intraregional, and local trip information to assist with calibrating and validating traffic models. Furthermore, O&D traffic data will allow for tracking and showing progress toward meeting passenger vehicle greenhouse emission reduction targets.
- Expanded traffic detection system will provide greater data granularity for evaluation of traffic patterns and trends.
- Installs the necessary vehicle detection infrastructure for future ramp metering implementation as well as positions the region for future congestion monitoring and traffic management.
- Recommended detection stations will be connected to a communication network that allows for quicker collection and dissemination of data. Data can be acquired quarterly or monthly and possibly be shared in "real-time" as future needs arise.
- The extended detection system will reduce field work hours for Caltrans Census staff.

Needs	Project Recommendations	Estimated Capital Cost	Estimate Annual O&M Cost
1. Make volume data more frequently available, at more locations, and at shorter time intervals	Upgrade existing temporary stations to permanent stations and install new permanent stations at locations without existing detection	\$3,096,000	\$139,000
	Deploy Global Packet Radio System in the short-term to bring detector stations online		
	Implement Traffic Monitoring Stations by installing detection equipment, controllers and communications equipment at permanent stations	\$290,000	\$197,000
2. Implement a tool to provide interregional, intraregional, and local Origin and Destination (O&D) trip information	Conduct Bluetooth pilot project and permanent system at County and SCUR gateways	\$510,000	\$58,000
	Integrate commercial off-the-shelf system to existing Caltrans system		
3. Create and implement tools to best utilize the existing traffic data collection system	Support Caltrans to upgrade existing functionality and process of Transportation System Network (TSN) and Performance Measurement System (PeMS)	Varies depending on features and scale.	Varies depending on features and scale.
	Support Caltrans to upgrade PeMS to automatically download census data from TSN. If the project for the PeMS upgrade is not anticipated in the near future, install third-party software data processing and reporting tool.		





TABLE OF CONTENTS

I.	INTRODUCTION.....	8
A.	Project Background.....	8
B.	Study Area.....	8
1.	SOUTH CENTRAL URBAN REGION (SCUR)	8
2.	GATEWAYS.....	8
C.	Real-Time Data Collection Background	10
1.	AGENCY BENEFITS.....	10
2.	USER BENEFITS.....	11
D.	Stakeholder Needs and Objectives.....	11
II.	EXISTING CONDITIONS	14
A.	Data Collection System.....	14
B.	Data Processing	16
C.	Data Storage and Reporting.....	17
1.	TRANSPORTATION SYSTEM NETWORK	17
2.	PeMS.....	18
3.	CALTRANS WEBSITE.....	19
III.	GAP ANALYSIS.....	20
IV.	SYSTEM EVALUATION AND FEASIBILITY	24
A.	Data Collection System.....	24
B.	Technology Evaluation.....	26
1.	INDUCTIVE DETECTOR LOOPS	26
2.	RADAR DETECTION	27
3.	VIDEO IMAGE DETECTION	28
4.	AUTOMATIC LICENSE PLATE READERS.....	29
5.	MAGNETOMETERS	30
6.	ACOUSTAL DETECTION	32
7.	BLUETOOTH	33
8.	RADIO FREQUENCY IDENTIFICATION (RFID) TAG READERS.....	34
9.	GPS BASED TRAFFIC DATA.....	34
10.	COMMUNICATIONS INFRASTRUCTURE.....	36





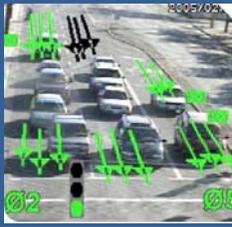
- C. Other Implementation Considerations..... 37
 - 1. END USE OF REAL-TIME DATA..... 38
 - 2. EXISTING POWER COMMUNICATIONS INFRASTRUCTURE..... 38
 - 3. DETECTION LOCATION AND SPACING PER DATA TYPE..... 41
 - 4. CONSTRUCTION IMPACTS ON TRAFFIC 41
 - 5. LIFECYCLE AND RECURRING COSTS 41
- D. Data Processing 41
- E. Data Reporting..... 43
 - 1. THIRD PARTY CENTRAL SYSTEMS AND DATA AGGREGATORS..... 44
- V. IMPLEMENTATION PLAN..... 48
 - A. Alternatives Analysis 48
 - B. Implementation Plan 49
 - 1. EXISTING CONDITIONS..... 50
 - 2. FUTURE CONDITIONS..... 53
 - C. Operations and Maintenance Plan..... 53
 - D. Funding..... 54
- VI. SUMMARY..... 57

LIST OF FIGURES

- Figure 1: Shasta County SCUR..... 9
- Figure 2: Caltrans QuickMap..... 20
- Figure 3: Typical Count Station Configuration..... 51

LIST OF TABLES

- Table 1: Estimate of Probable Operations and Maintenance Costs for Hardwire Power (Per Location)..... 39
- Table 2: Estimate of Probable Operations and Maintenance Costs for Solar Power (Per Location) 40
- Table 3: Estimate of Probable Communication Costs..... 40
- Table 4: Gaps and Preferred Alternatives..... 49
- Table 5: Summary of Proposed Project Costs..... 58

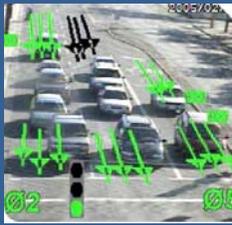


LIST OF APPENDICES

- Appendix A: Existing Count Station Locations
- Appendix B: Technology Overview
- Appendix C: Alternatives Analysis Table
- Appendix D: Recommended Projects Table
- Appendix E: Proposed Projects

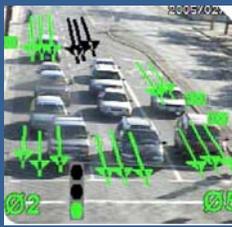
LIST OF REFERENCES AND RELATED DOCUMENTS

1. Traffic Monitoring Guide (TMG)
2. Update of Guidelines and Operating Procedures for the Traffic Volumes Program – Cambridge Systematics, September 10, 2008
3. Highway Performance Monitoring Program (HPMS) Field Manual
4. State Procedures for Developing K-factors, D-factors, and Percent Trucks
5. Freeway Ramp Metering Implementation, District Directed – Dated April 18, 2008



GLOSSARY AND ACRONYMS

Acronym/Term	Definition
AADT	Annual Average Daily Traffic
ALPR	Automatic License Plate Reader
ATMS	Advanced Traffic Management System
BTS	Berkeley Transportation Systems
CCTV	Closed Circuit Television
Census Program	A federal traffic data collection program that gathers traffic data for estimating AADT, AADT by vehicle class, axle loads, and vehicle miles of travel (VMT). Guidelines include the Traffic Monitoring Guide (TMG), Highway Performance Monitoring Program (HPMS) Field Manual, and State Procedures for Developing K-factors, D-factors, and Percent Trucks.
CFCD	Cellular Floating Car Data
CHIN	Caltrans Highway Information Network
CLS	Classification (Data File Extension)
CMS	Changeable Message Sign
CNT	Count (Data File Extension)
CSV	Comma-Separated Value (Data File Extension)
CWWP	Commercial/Media Wholesale Web Portal
ETC	Electronic Toll Collection
FEPT	Front End Protocol Translator
FHWA	Federal Highway Administration
FMCW	Frequency Modulated Continuous Wave
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
GPRS	General Pocket Radio System
GUI	Graphical User Interface
HAR	Highway Advisory Radio
ID/DAT	Identification/Data (File Extension)
Integrated Traffic Data Collection System	A data collection system that provides accurate and current traffic data for planning purposes as well as a means for making Traffic Operations more efficient
ISDN	Integrated Services Digital Network
ITS	Intelligent Transportation Systems
LCS	Lane Closure System
MAC	Media Access Control
MVDS	Microwave Vehicle Detection System
Non-Permanent Count Station	Census count station where inductive loops have been installed and a Diamond counter is only deployed during scheduled count period
O&D	Origin and Destination
OCR	Optical Character Recognition



GLOSSARY AND ACRONYMS

Acronym/Term	Definition
PeMS	Performance Measurement System – Online portal for accessing vehicle detection data and conducting analyses.
POTS	Plain Old Telephone Service
Permanent Count Station	Census station where inductive loops, controller cabinet, and counter have been installed. Station continuously collects traffic data.
Real-time Data Collection	For District 2 and SRTA, real-time data collection refers to providing frequent access to traffic data within the SCUR including volume, speed, and O&D at gateways and other key points.
RFID	Radio-Frequency Identification
RITA	Research and Innovative Technology Administration
SCUR	South Central Urban Region
SMS	Short Messaging Service
SRTA	Shasta Regional Transportation Agency
TMC	Traffic Management Center
TMS	Traffic Monitoring Stations
TSN	Transportation System Network
VCR	Type of file format to which traffic data is exported to
VIP	Video Image Processor
VMT	Vehicle Miles of Travel
ZigBee	A low cost and low power wireless mesh network standard often used as communication between a sensor and its control unit.



I. INTRODUCTION

A. Project Background

Reliable, accurate, and quality traffic data collection is the cornerstone for planning, developing and managing an effective transportation system. Caltrans District 2 currently maintains a census program that collects vehicle volumes and classification counts per Federal Highway Administration (FHWA) traffic monitoring data collection guidelines and standards. The current system is limited in its ability to relay and disseminate the data in a timely, efficient, and widely accessible manner that can be useful to the Shasta Regional Transportation Agency (SRTA) and partner agencies for planning activities. With anticipated future growth in the South Central Urban Region (SCUR), the SRTA and Caltrans District 2 (D2) desire to develop a vision for a data collection system that would provide accurate, timely, and reliable data. This system will be crucial for use in planning, developing, and managing the transportation system throughout the County; now and into the future. The purpose of this implementation plan is to detail the existing data collection system and processes, identify stakeholder needs and goals, present an evaluation of data collection tools and technologies, and identify potential system deployment strategies and approaches through specific projects.

B. Study Area

1. SOUTH CENTRAL URBAN REGION (SCUR)

The SCUR is the region surrounding and including the urban centers of Redding, Shasta Lake, and Anderson. It stretches north-south along I-5 from just north of Mountain Gate to the Shasta/Tehama County Line. The eastern border is just beyond Palo Cedro, Bella Vista and Jones Valley while the western borders are just west of Old Shasta and Centerville. The major freeway backbone for the entire region is Interstate 5. California State Routes 44 and 299 are the primary east-west corridors. **Figure 1** below shows a map of the SCUR with all three of Shasta County's urban centers highlighted.

2. GATEWAYS

Shasta County has seventeen points of entry/exit by which vehicles travel to and from the County. For the purposes of this study and based on discussions with Caltrans and SRTA, the following locations were identified as the main urban gateways by which the vast majority of vehicles enter and exit the SCUR. All gateway references in this document will be in reference to the locations below. The gateways locations are displayed in **Figure 1** below.

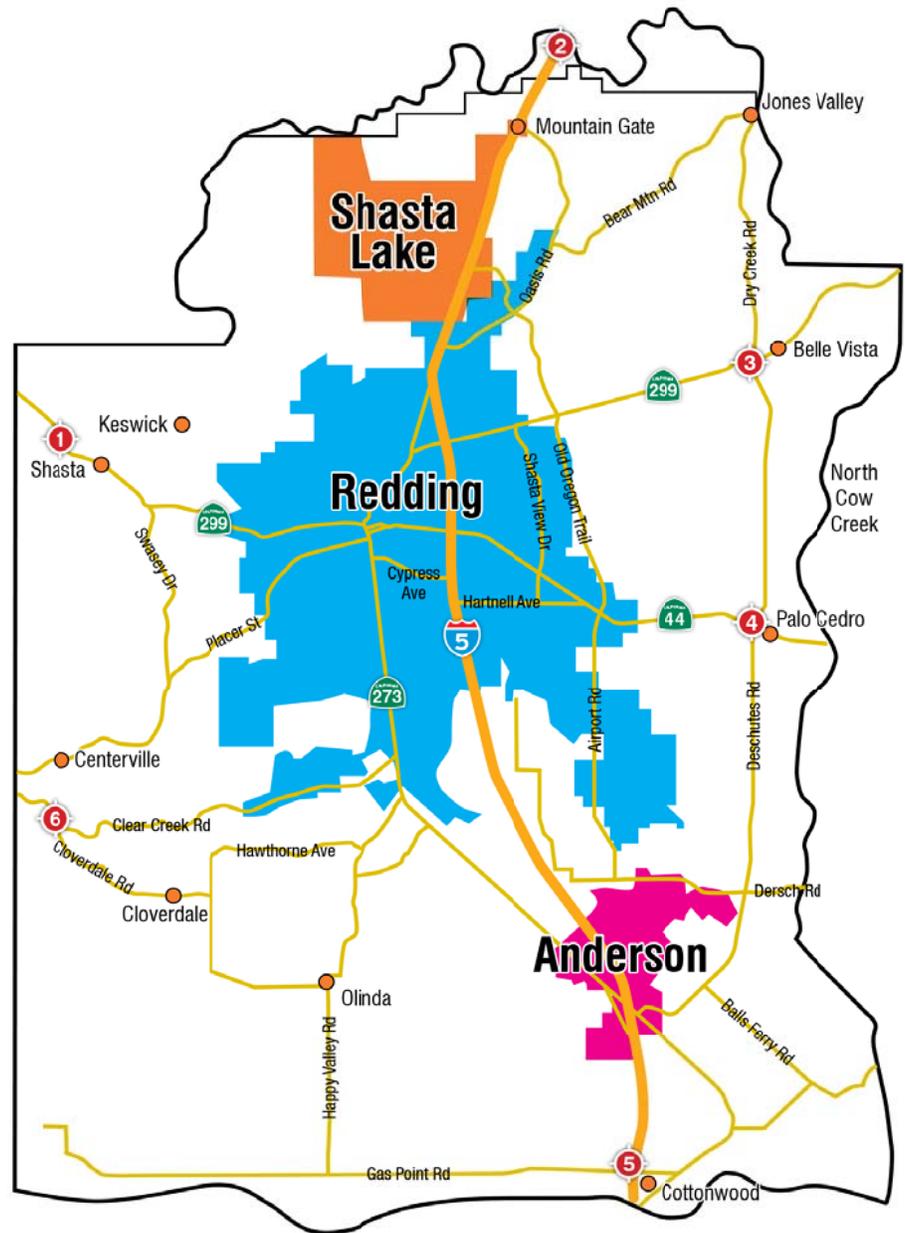
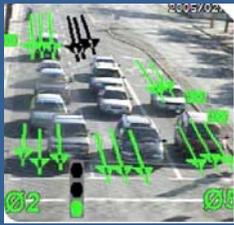
Gateway 1: Highway 299 west of French Gulch Road;

Gateway 2: Interstate 5 south of Fawndale Road;

Gateway 3: Highway 299 east of Dry Creek Road;

Gateway 4: Highway 44 east of Deschutes Road; and

Gateway 5: Interstate 5 north of Bowman Road.



LEGEND

- North
- Gateway
- Town/City
- SCUR Boundary



Figure 1: Shasta County SCUR



C. Real-Time Data Collection Background

A real-time data collection system provides benefits that can be realized by agencies as well as roadway users. For agencies, this can provide a source for more frequent traffic data to provide better transportation planning; faster incident detection, response and clearance; the ability to monitor traffic flow on alternate routes; faster analysis and resolution of traffic flow issues; and performance monitoring. For users, this means improved safety, reliable travel time data, and reduced congestion.

Real-time data collection systems can vary in data collection and output capabilities depending on stakeholder data requirements. For purposes of this project and pertinent to District 2 and SRTA, the real-time data collection system is needed to provide frequent access to traffic data within the SCUR including volume, speed, and origin/destination data at gateways and other key points within the SCUR. This would consist of a system that would continuously collect data and compile it once a quarter or as needed. These counts would primarily be used for planning and traffic modeling purposes. *For purposes of this document, the proposed system will be referred to as an **Integrated Traffic Data Collection System**.* An Integrated Traffic Data Collection system is one that provides accurate and current traffic data for planning purposes as well as a means for making traffic operations more efficient.

An **Integrated Traffic Data Collection System** is one that provides accurate and current traffic data for planning purposes as well as a means for making traffic operations more efficient.

Below is a discussion of the benefits that an integrated traffic data collection system would provide to stakeholders.

1. AGENCY BENEFITS

Accurate and timely traffic data benefits transportation planners and traffic engineers. Transportation planners benefit from reliable and current vehicle data to model impacts on the region. Traffic engineers can utilize lane-by-lane freeway and on-ramp data to pinpoint areas of recurring congestion, collect traffic data to measure levels-of-service, and measure increasing congestion levels that may warrant ramp metering. Having access to relevant traffic data can also enable engineers and planners to respond to and resolve issues quicker and help them create proactive solutions that address likely traffic issues before they happen.

Integrated data collection and distribution coverage across multiple jurisdictions is critical in providing vehicle traffic data that is relevant and useful. While agencies do not need to use the same technologies, having communication protocols for sharing information can be critical to maintaining consistent and reliable information amongst data users. An enhanced data collection and dissemination system decreases the amount of time required to process and distribute data, and will provide an ability to share information across multiple communication platforms with several options for automated data collection and sharing between agencies.

Many of the benefits of enhanced data collection provide indirect benefits that address SRTA's regional transportation goals. The SRTA 2010 Regional Transportation Plan identifies the following expected benefits of integrating ITS into the transportation network:





- Improved Safety – Accurate and reliable traveler information will reduce secondary accidents.
- Improved Emergency Response – Detect incidents quicker.
- Improved Commercial Vehicle Operations – Increased availability of commercial vehicle traffic data to help identify measures to improve movement of goods throughout the region
- Increased Travel Information and Trip Enhancement – An enhanced data collection system will position the region for future deployment of accurate and reliable traveler information that drivers will demand.
- Improved Interagency Communications – Data is easily shared and accessed by multiple partner agencies.
- Reduced Congestion – Fuel consumption and greenhouse gas emissions are reduced.
- Increased Economic Activity – Better mobility through the region will improve economic activity.

Many of these anticipated benefits will be achieved by providing an enhanced data collection system that allows for transportation planning professionals to realize these benefits.

2. USER BENEFITS

An expanded data collection system will ultimately provide benefits to users through more-informed transportation planning. Traffic congestion occurs whenever vehicle demand nears or exceeds the capacity of a roadway. Traffic congestion is generally characterized by reduced speeds, increased travel times, and vehicle-hours of delay. Traffic congestion has economic and environmental impacts, whether in metropolitan or rural areas. Traffic delays, due to saturated demand or incidents, waste time and fuel, which are quantifiable in both dollars and greenhouse gas emissions.

When transportation planning agencies have better data for modeling, growth strategies are more tangible and pertinent. Users will see relevant expansion in the transportation network and infrastructure as a result of using more current data for development strategies. Purposeful planning will mitigate congestion, enhance user mobility throughout the region, get people and goods to their destinations faster, and allow people to spend more time at their destinations; rather than in traffic.

D. Stakeholder Needs and Objectives

In order to understand and document gaps in the existing data collection system, stakeholder needs and objectives must be clearly defined. A workshop was conducted with Caltrans District 2 and SRTA staff to discuss and prioritize overall data collection goals and objectives. While District 2 currently provides a fully sufficient, up-to-date traveler information system by utilizing Closed Circuit Television (CCTV) cameras, Changeable Message Signs (CMS), and Highway Advisory Radio (HAR); the overall goal of stakeholders at this time is to plan for an accurate, timely, and reliable data collection system that collects, compiles and distributes vehicle traffic information on the highway system within the urban region of Shasta County. According to stakeholders, there currently is not a need to develop a traveler information system that provides congestion levels and travel times/speeds, based on Traffic Monitoring Stations (TMS), although this would be desirable when the region experiences sustained congestion levels. Periodic evaluations should be made as the region's growth and congestion increase to identify when it will be needed.



The discussion below consists of a summary of the stakeholder needs as determined by stakeholder input in the workshop. Following each need is a discussion of the desired uses and applications that would be provided if or when the needs are met. The recommended data applications or processes are categorized to highlight whether they are applicable to transportation planning or highway operations activities.

Need #1: Make volume data more frequently available, at more locations, and at shorter time intervals.

Transportation Planning:

For long-term planning and performance monitoring purposes, a more expansive network of frequently updated vehicle data collection that captures and reports traffic volume data on a regular basis will allow SRTA and Caltrans Planning accurate historical data for project and economic development, regional connectivity, traffic impact analyses, traffic demand modeling, and mobility trends. There is also a desire to collect on, off, and through counts at each major interchange along I-5. Additional volume data includes vehicle classification counts and vehicle speed data. SRTA and Caltrans Planning would prefer that volume data be continuously collected and available within three to six months of collection. The enhancement of data availability is a top priority for the various planning groups, and a system where the required data is collected in conjunction with efficient data processing is an objective that will increase the planning capabilities of all agencies.

District Directive DP-09 outlines the requirements for planning and implementing a ramp metering program and sets ramp metering implementation levels based on mainline peak vehicle density. Under this Directive, District 2's Office of System Planning is tasked with forecasting when ramp metering implementation will be required. Although ramp metering throughout the SCUR and District 2 is not warranted at this time, Caltrans needs to monitor the progress of growth in vehicle density along the region's freeways. Ramp metering preparation would be achieved through an expanded data collection system. In line with providing for future ramp metering, a District 2 policy requires that all new interchanges must be designed to accommodate metering. Currently, one ramp meter was installed in Redding in 2010 at the Dana Drive on-ramp to westbound CA-44, but this ramp meter is inactive because traffic volumes and delay do not warrant ramp metering.

Highway Operations:

Caltrans has identified a future need to collect and display real-time volume data on I-5 and select count gateways when recurring congestion duration increases. At that time, Caltrans would like to increase the volume data collection frequency and availability in order to monitor – in real-time – traffic conditions to proactively detect incidents and minimize response and lane closure times. An expanded traffic monitoring system would increase the granularity of vehicle data collected along each corridor. Traffic monitoring systems used for congestion monitoring utilize TMS that continuously collect on, off, and through counts at each major intersection. A central system automatically polls and retrieves the data from the TMS. Highway operations could benefit from the ability to monitor volumes on detour and



alternate routes resulting from both recurring and non-recurring congestion and/or construction by having up-to-date traffic data on interchanges that can be used for such detours.

Volume data along the freeway mainline and at on-ramps and off-ramps is crucial to operating a ramp metering program. As mentioned in the Transportation Planning discussion above, ramp metering is not currently warranted throughout the SCUR and District 2. However, because there is a potential need for ramp metering in the future, Caltrans desires an expanded data collection and traffic monitoring system that will accommodate a ramp metering program in the future.

Need #2: Implement a tool to provide interregional, intraregional, and local Origin and Destination (O&D) trip information.

Transportation Planning:

One of the highest priorities for both SRTA and Caltrans' System Planning is to report interregional, intraregional, and local origin and destination travel patterns. This need is particularly crucial as gateways are the most important factor to the planning activities related to the Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375) and other funding considerations. A system that can collect and export O&D information would aid in establishing trend lines in goods movement, GHG emissions, and prevailing traffic patterns on an annual, seasonal, and daily basis. O&D monitoring would help analyze weekday versus weekend traffic trends and can validate regional transportation planning projections and development. This O&D system would include select County gateways and SCUR gateways. Monitoring the county gateways is important in understanding the overall traffic patterns as it relates to the surrounding counties. The need to monitor SCUR gateways is of high importance for planning agencies in order to gain a more focused understanding of the urban region's traffic patterns, since the SCUR is where the heaviest vehicular traffic occurs and where approximately 85% of the region's population lives.

Highway Operations:

An Origin and Destination system has not been identified as a need by the Highway Operations stakeholders at this time.

Need #3: Create and implement tools to best utilize the existing traffic data collection system.

Transportation Planning:

There is a desire by SRTA for a reporting system that would allow for easy access to data and would be user friendly. The reporting tool would allow users to readily access current traffic data and make conclusions on capacity, demands, and problem locations. Evaluation tools are desired in order to allow



planning agencies to identify when roadways will exceed capacity as it relates to both historical and real-time trends. Such tools would help to identify bottleneck locations throughout the region.

Another tool that SRTA has expressed a need for is one that would allow users – whether SRTA staff or the local public agencies – to query data for customized transportation-related reports. This data tool would maximize system flexibility and applicability to multiple department/ agency needs and desires. It would also reduce custom requests made to District staff members, standardizing the process for how transportation planning data is distributed to consultants and the general public.

Lastly, the District has the need to archive and distribute traffic information such as delay, travel time, speed, volume, and congestion levels. This need stems from the desire to quantify the effects of capacity constraints, recurring and non-recurring congestion, and construction. An archiving and reporting system is necessary to create a historical database that enables planning agencies to access and define regional-specific and region-wide travel behavior.

Highway Operations:

A system that monitors real-time delay and congestion levels is desired by the District, but not until some point in the future when recurring congestion is more prevalent in the SCUR during longer peak periods. This tool would quantify the effects of capacity constraints and provide users with real-time information to make informed route decisions when traveling. In the future, the need for a short messaging service (SMS) has been expressed. Once recurring congestion is prevalent, SMS would provide the capability for the TMC or other operational staff to alert emergency responders when necessary; this would minimize response and blockage time and reduce congestion on travel ways.

Because of annual winter weather delays due to the closing of Interstate 5 north of Redding, a key desire by the District is a travel time tool specifically for when inclement weather forces speeds to drop on I-5 and/or when weather requires partial closure of the freeway. Such weather-induced incidents are frequent in the Shasta region and can also be caused by summer wildfires. A tool that can alert travelers and provide predicted delay time would help in allowing them to make informed travel decisions.

II. EXISTING CONDITIONS

A. Data Collection System

Caltrans District 2 collects vehicle census data using in-pavement loop detection, temporary tube counters, and piezoelectric sensors (data collection technologies are described in Section IV below). Data collection consists of volume count and vehicle classification (number of axles). There are 660 count stations district-wide; the Caltrans Census Team utilizes about 90 Diamond[®] counters to collect data from these sites.

There are several different types of traffic count data collected by the Census Team. Each type of traffic count has a specific duration and data submittal frequency. The following list describes the existing count stations that are located within the SCUR:



- 16 permanent stations for continuous counts, known as trend counts, that remotely collect and transmit data via dial-up or cellular modem and submitted to Caltrans Headquarters on a monthly basis;
- 14 quarterly stations (2 of which are permanent), known as control stations, have seven-day count durations collected four times per year, once every three years;
- 18 profile counts are collected for one week every three years;
- 92 ramp counts are collected for two weeks every three years; and
- 14 classification stations, used to classify vehicles by number of axles, are completed in a seven day period on a yearly basis.

Appendix A is a map that shows the locations of these existing count stations.

Caltrans deployed two permanent test sites of Microwave Vehicle Detection System (MVDS) stations along I-5 near Knighton Road. These MVDS stations are not currently operational due to integration and data validation concerns by Caltrans District 2. Caltrans District 2 does not have any Traffic Monitoring Stations (TMS) within the SCUR.

All existing census stations are fully operational, with the exception of several stations along I-5 that are currently being reinstalled due to construction. When operational issues with a station are identified, steps are immediately taken to solve the issue.

The majority of the existing permanent stations utilize dial-up modems for communications, though several utilize cellular modems. District 2 currently utilizes a combination of wireless microwave and dial-up for existing CCTV cameras, and is in the process of enhancing its communication network through the use of a licensed microwave wireless network. Caltrans has plans to install a fiber optic backbone cable along Interstate 5; construction is estimated to be completed by 2016.

There are instances where the District receives requests for counts at a specific area in a specific time frame. These counts, known as Special Count Requests, are done on an as-needed basis and are submitted to the party of interest. All count data (except Special Count Requests) is submitted to Caltrans Headquarters as it is collected.

Caltrans District 2's Census Team employs a mix of standard federal, state, and District specific data collection procedures and practices. The Census Team works year-round to collect and process traffic data, and make it available for use by the public and other agencies. As a guideline for Annual Average Daily Traffic (AADT) volume data collection and reporting, the Census Team has referred to the "Update of Guidelines and Operating Procedures for the Traffic Volumes Program" report created by Cambridge Systematics. The report details statewide procedures on traffic counting and Transportation System Network (TSN) data management; however, according to the District 2 Census Coordinator, this report does not serve as a strict manual for the District as they have implemented other District-specific procedures that have been in effect for many years. The Census Coordinator has created informal documents for certain steps of the traffic volumes program, but none of these documents have been standardized or compiled into a single, official operating procedures manual. Since there are no official documented procedures for collecting traffic, a separate *Policy and Procedure Manual* has been developed in conjunction with this Implementation Plan.



Depending on data collection locations, field visits are required to deploy equipment or download data. For non-permanent count stations, the Census Team travels to the station and deploys a counter that collects the traffic data. The counter collects data for one week and is then retrieved by the Census Team to extract the data and download it using traffic count software. In some cases, such as for quarterly count stations, road tubes are installed instead of permanent counting devices. The Census Team deploys both tubes and counters for a designated duration before retrieving the equipment and downloading the traffic data. For permanent stations collecting trend counts, the Census Team has the capability of collecting the data in one of two ways: in-field connection or dial-up modem connection. Either method will download the data without the need to deploy counters, since counters are permanently installed at these locations. The former method requires a physical connection to the station's controller while the latter can be done through remote connection with the Census office at Caltrans District 2. For ease and convenience, the Census Team utilizes the remote connection method; however, should a connection be unstable and data is not polled correctly, the team troubleshoots in the field and downloads the count data through direct connection. Both methods use Diamond's TT-Link program to communicate with the count station, retrieve the count data, and convert the data into useable files.

Caltrans District 2 maintains and manages the Loop List database in Microsoft Access which documents various attributes for all census locations within the District, including those within the SCUR study boundary. The database stores general roadway information including route number, postmile, latitude/longitude, elevation, roadway type, number of lanes, primary direction, and location description. The database also documents count station details, such as site number, leg, station type, detector type, pull box postmile, number of loops, description, other notes, as well as maintenance log, pictures, sketches, land maintenance date, and year of installation.

Though existing census station information had not previously been mapped using ArcGIS, this project has created a GIS shapefile for existing District 2 census stations based on the information provided in the Loop List database in Microsoft Access. Mapping of existing census stations was achieved through the use of latitude/longitude coordinates (decimal degree format) in the Loop List Access database and based on input from District 2's Census Team. The projection is NAD_1983_HARN_StatePlane_California_I_FIPS_0401_Feet. With this shapefile, SRTA and Caltrans will have a mapping tool to continuously build upon the existing data collection infrastructure as it expands over time. This data is compatible with other county ArcGIS data formats and spatial projects. The GIS spatial data can replace the previous Microstation census station map.

B. Data Processing

Once the traffic data has been downloaded, data processing begins. The Census Team follows a precedent of undocumented procedures for processing collected count data in order to meet Federal Census data requirements. These processes have been refined throughout the years by the current Census Coordinator to improve data collection efficiency. When data is extracted from the counters, it is in the form of classification and count files (CLS and CNT file extensions). Sensor misses and errors are placed in separate files. The Census Team primarily uses Diamond's Trafman, a DOS program, and converts the data from Diamond's native file format by downloading the data from the counters into VCR files (classification) and ID/DAT files (volume). VCR and ID/DAT files are sent to Caltrans Headquarters where they are uploaded into the Caltrans TSN. Classification files are sent to headquarters first since these files



exclude vehicles that could not be classified due to sensor error. Volume files are sent separately and include all vehicles regardless of classification and therefore provide a true volume count. Volume figures from these ID/DAT files will update and override volume figures from previously submitted VCR files. Upon receiving these files from the District, Headquarters uploads them into TSN. If an uploading error occurs, the Census Team is alerted through email and begins troubleshooting. The combination of both VCR and ID/DAT files in TSN provides a comprehensive and accurate reporting database.

Typically, vehicle count data is available in TSN within 6 weeks from when the counts are conducted. A summary of the tasks that must take place over this time period are as follows:

1. Caltrans District 2 staff manually retrieve the data from all non-permanent and permanent count stations;
2. Caltrans District 2 staff manually compiles the data and sends to Caltrans Headquarters; and
3. Caltrans Headquarters' staff posts data to TSN.

Based on conversations with Caltrans District 2 staff, the data collection and processing operates as efficiently as possible given current staffing levels and equipment.

Along with actual count data collection processing described above, District 2 follows a set schedule for first and final rounds of AADT submittals, and ramp and truck AADT updates. From October to January, the Census Team quality checks the information that was placed into TSN from the previous fiscal year. Data from Diamond counters are compiled into an Excel spreadsheet using Centurion. Centurion is a traffic management program from Diamond similar to Trafman, but on a Windows platform rather than DOS. The Census Team compares the spreadsheet data with the TSN data for accuracy. Corrections are made to the TSN data if necessary. By mid-January, the traffic data is used to create the first draft of the AADT Report due to Caltrans Headquarters. By March, the final report is submitted, where it is passed onto Federal agencies that make them available for public use.

C. Data Storage and Reporting

1. TRANSPORTATION SYSTEM NETWORK

The Transportation System Network (TSN) is a system that integrates traffic volumes, incidents, performance monitoring, and pavement management into a single application. Historical data is stored and can be queried by users to develop customized reports that are compatible with MS Office programs. Data reports can include daily and hourly summaries as well as volume rankings for any user-defined time period and data collection station within the system.

Caltrans heavily relies on this data for historical analysis and planning purposes, but the data is not typically available until Headquarters further validates the data and posted it in the TSN database. Typically, the time period between collecting the data from the field to the posting of data on TSN is about 6 weeks.

SRTA does not currently have access to data posted on TSN. Instead, SRTA must either wait for data to be posted on PeMS, use published AADT reports (which are only posted on a yearly basis), or make special



requests for data from Caltrans District 2. Due to staffing and other workload constraints, special data requests strains District 2's already restricted resources.

2. PeMS

Caltrans Performance Measurement System (PeMS) is a statewide freeway data storage and dissemination system. PeMS was developed originally by Berkeley Transportation Systems (BTS) and is now currently a product of Iteris. PeMS uses traffic data from over 25,000 detectors throughout California capable of assisting professionals in long-term planning and transportation analysis.

There are two versions of PeMS – one openly accessible and one for registered users that has restricted permissions on data access. The openly accessible version (pems.dot.ca.gov) displays current traffic conditions and messages currently displayed on changeable message signs. There is currently no information displayed in the SCUR on the openly accessible version of PeMS. PeMS for registered users provides the same information and also allows users to pull traffic counts, VMT, delay and other variables for road segments in multiple report forms for analysis or display. To access this restricted site, users must first apply for an account. To apply, a user must click on the “apply for an account” link on the PeMS log-in page and fill out the registration form. Within 1-2 business days, submitted applications are reviewed and either approved or rejected. If approved, an e-mail with a computer-generated password will be sent to the applicant; this password will enable the user to log into PeMS. This password may be changed after logging in.

It is Caltrans' policy to allow PeMS access to members of the public, academia, and private and public institutions, so long as the user adheres to the Terms of Use. Caltrans' Terms of Use can be found on the registration page.

PeMS operates through two variants – real-time and count. The difference in the two variants is entirely dependent upon the communications infrastructure deployed by the agency. Real-time loop data in the form of count and occupancy is the primary focus on PeMS and is only available from vehicle detection stations that can create speed or occupancy data (i.e., inductive loops, magnetometers, radar). Real-time data has a 15-minute latency threshold and is generally limited to urbanized areas with recurring congestion. In other areas, census count data is the only available data, and it is not considered “real-time” data due to the frequency it is available.

Count data can be used in areas without real-time data but it is less detailed and timely. With real-time data, 30-second loop detector data is the primary input into PeMS. Speed, vehicle miles of travel (VMT), and travel time are calculated for a 5-minute average for each road link.

For count data, there can be a significant lag between the time in which data is collected and when it is available on PeMS. This is because data from Transportation System Network (TSN) is only manually imported once or twice a year into PeMS. Therefore, there may be a delay of one year or more between when data is posted to TSN to when it is made available on PeMS. Per discussions with the Chief of PeMS at Caltrans Headquarters, this process may become automated in the next couple years. This would make the data on PeMS as current as the data on TSN.



Data is shown primarily through a map-based GUI for both users. For professional users, PeMS includes a built-in table with graphing tools as well as multiple export options. Users can navigate through PeMS' options to find specific data on field elements that exist on a freeway. Elements such as controllers, stations, detectors, and traffic census stations are listed for each freeway and includes data such as post mile, element ID, type of station (e.g. mainline or on-ramp), and what data the station collects (e.g. volume or classification). By clicking on a specific station ID, users are brought to a summary page where they can view station details including the installation date, sensor type, and retrieval method. Large archived data sets can be downloaded for modeling and statistical analysis. For instance, volume data can be retrieved and manipulated to report the information through time-space diagrams, time-series diagrams, time-of-day, time-of-week, or hourly counts. Other versions of the data can be exported to show the data as a plot, a table in a web browser, a text file, a CSV file, or a "flat file" (real-time data only) which contains data that has gone through a data clearinghouse.

Not all field elements in a particular freeway will have all the data that PeMS is capable of providing. The availability of detailed data on specific field elements depends on factors that include the elements' health, the frequency that data is polled from the field element, and the frequency that the data is uploaded to PeMS. The accuracy and usefulness of PeMS data is highly dependent on the completeness of data being collected in the field and processed. PeMS has an adaptive g-factor algorithm to provide accurate speed estimates but does not include other error checking algorithms or error flagging tools. Users require instruction and training to understand how to navigate PeMS and to apply the data accessed through PeMS.

3. CALTRANS WEBSITE

The Caltrans District 2 website (dot.ca.gov/dist2/) currently offers several maps with travel information in the region. Information provided via the District 2 website includes lane closure information, incidents, CMS messages, CCTV camera still shots, and chain control requirements. Data is updated on the website approximately every 5 minutes.

There are also links to the following:

- Caltrans Highway Information Network (CHIN) – This interactive map provides a summary of traffic alerts (e.g., road construction, chain requirements) along each state corridor for the entire length of the corridor. This information can be a little tedious for a corridor such as I-5 which runs the entire length of the state. This information cannot be exported separately from the website.
- Traffic Cameras and Road Weather Information – This interactive map provides locations of CCTV cameras and RWIS stations. When clicked, a pop-up window displays a camera image and weather information (where applicable). This information can be exported separately from the website using specific export feeds.
- CMS Messages – An interactive map provides locations of CMS. When clicked, a pop-up window displays current messages displayed on a sign. This information can be exported separately from the website using specific export feeds.



Also available on the District 2 website is a link to Caltrans Headquarters QuickMap (quickmap.dot.ca.gov/) that displays traffic congestion conditions for I-5 and portions of Highway 44 and Highway 299 (see **Figure 2**). The QuickMap utilizes traffic information from Google Maps that partially utilizes Caltrans data as well as cellular phone data and other private data sources. According to Caltrans District 2 staff, the QuickMap traffic information tends to have a lag time of 15 minutes compared to actual traffic conditions.

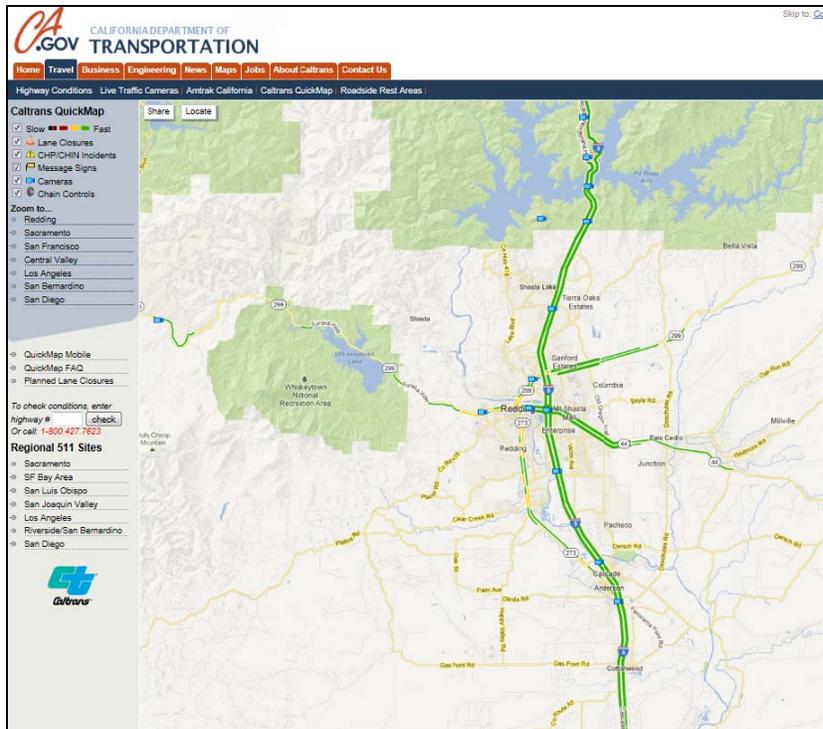


Figure 2: Caltrans QuickMap

Caltrans does provide the public direct data access to traveler information data for third party usage; the data is available through the Commercial/Media Wholesale Web Portal (CWWP). Caltrans District 2's CCTV, CMS, Lane Closure System (LCS) and RWIS data is available for export using the following links:

- Closed Circuit Television: dot.ca.gov/cwwp2/documentation/cctv/cctv.htm
- Changeable Message Sign Messages: dot.ca.gov/cwwp2/documentation/cms/cms.htm
- Lane Closure System: dot.ca.gov/cwwp2/documentation/lcs/lcs.htm
- Roadway Weather Information Stations: dot.ca.gov/cwwp2/documentation/rwis/rwis.htm

III. GAP ANALYSIS

The intent of this section is to identify gaps in the current overall process that result from unnecessary delays, inefficiencies, or restricted functionality. Gaps are specifically representative of the physical or functional differences between existing conditions and desired functionality. This section highlights the limitations in existing infrastructure or procedures that may prevent SRTA or Caltrans D2 from meeting the objectives defined above.

Need #1: Make volume data more frequently available, at more locations, and at shorter time intervals.



Gap #1: Majority of count stations are non-permanent and do not collect continuous counts.

The current census data collection infrastructure is built to meet the requirements of the federally mandated Census Program. Under that program, much of the volume data is only required to be collected every three years for a short period of time, but the stakeholders need more recent data (preferably 3-6 months old). Currently, there are only two Census staff members responsible for the entire process of collecting, processing and reporting census data. The Census Team has developed an efficient process to quicken the various tasks required; however, a large amount of time is still spent manually collecting data from every count station. Non-permanent stations require the team to physically set up Diamond counters to poll data, while downloads from permanent stations can be initiated from the Census office. Though permanent stations don't require extra time to manually deploy and retrieve counters, the process can still be optimized by implementing a system where the need to manually poll data by phone is bypassed. The manual data collection nature of non-permanent count stations is preventing the District from more efficiently collecting volume data. However, the District has been limited in deploying permanent stations due to the initial costs of permanent stations for the installation of infrastructure and equipment as well as the recurring costs for maintenance, power, and communications.

Given the limited staffing and extensive duties, there is very little room to expand or optimize the existing data collection process. Any addition of new data collection stations or increasing the frequency of data collection to meet the stakeholder's data needs is beyond the current staffing capabilities. Upgrading non-permanent count stations with permanent counters or controllers will reduce the amount of field work required for the Census Team and help the stakeholders achieve the need for more frequently available data.

Gap #2: Lack of permanent count stations installed at locations where data is most desired.

The District lacks permanent count stations that can continuously poll data between major interchanges along I-5, such as between Knighton Road and South Bonnyview Road, Route 44 and Route 299, Route 299 and Twin View Boulevard, Oasis Road and Pine Grove Avenue, and Pine Grove Avenue and Route 151. Since the need to regularly capture volume data between interchanges and at ramps is a priority for the District, it is necessary to analyze the current count station locations and fill in gaps where inventory is lacking.

Gap #3: Limited communication network to allow for regular polling of data.

The current configuration of the vehicle count infrastructure cannot be utilized for providing continuous data. There is currently no direct data dissemination to a Traffic Management Center (TMC) or Advanced Traffic Management System (ATMS). Since data collection is currently done through on-site data download, periodic data collection, or dial-up (cellular or telephone) download, the system cannot provide frequent data without further investment in communications equipment. Dissemination of data would need to occur through direct network communication – private wireless, direct fiber line, integrated services digital network (ISDN) telephone or a private cellular network are all options. As part of upgrading existing non-permanent count stations, these locations should be equipped with a communication device in order to provide more frequent, continuous data. However, as it is already a constraint to Caltrans District 2, installation and recurring costs of an expanded communication network



will remain a key factor in deployment of an expanded data collection system. Communication solutions will need to be evaluated on a location by location basis to determine which will best serve the needs while not being cost prohibitive.

Need #2: Implement a tool to provide interregional, intraregional, and local Origin and Destination (O&D) trip information.

Gap #4: *There is no equipment to track traffic into, out of, and within the County.*

Currently, there are classification stations throughout District 2 that provide some information on vehicle movement by type of vehicle throughout the County. Unfortunately, this data only consists of volume counts and does not provide the granularity of origins and destinations. Permanent data collection stations are not able to collect O&D data nor is there a central data processing system that can disseminate O&D data. Specialized data collection stations with the ability for continuous communication must be deployed to provide continuous O&D data needed by SRTA and Caltrans planning groups. This type of tool will be essential to SRTA for calibrating and validating their traffic modeling in the future. This will assist SRTA in tracking and showing progress toward meeting passenger vehicle greenhouse gas emissions reduction targets.

Gap #5: *There is no central system for reporting traffic data into, out of, and within the County.*

Caltrans currently conducts manual data collection of origins and destinations to determine the flow of vehicles and goods. If origin and destination data is collected by field equipment, a central database and reporting system is needed to archive the data and enable users to generate reports.

Need #3: Create and implement tools to best utilize the existing traffic data collection system.

Gap #6: *There is no Advanced Traffic Management System (ATMS) that can monitor real-time congestion levels, detect incidents, or convey regional travel time impacts due to inclement weather conditions.*

The current system has the ability to display travel information, incident warnings, and other messages on the District's existing changeable message sign (CMS) network. CMS are manually activated and controlled by the TMC operator as needed. There is currently no ATMS deployed in District 2 that can automatically compare real-time and historical data to anticipate and alert when congestion or incidents occur, though IRIS (Intelligent Roadway Information System), an open-source ATMS is anticipated to be deployed in District 2. No exact deployment date is scheduled at this time. This is currently a low priority to stakeholders.



Gap #7: No direct way for outside agencies to query or compile reports until data is posted to PeMS.

PeMS is a powerful tool to gather information; however, data querying is only possible if the data has already been posted by the collecting entity. Since Caltrans' data processing and procedures can take a significant amount of time to post to PeMS, agencies interested in the data need another source for requesting data that is more frequent. Caltrans Headquarters has indicated that PeMS does not automatically pull census information from TSN (although this feature is a currently planned Caltrans project). Instead, the data must be manually transferred and uploaded into PeMS after the data is validated in TSN using outdated legacy software. The data is manually downloaded to PeMS only once or twice a year. This process may add six to twelve months of delay on top of the required time to collect and validate the census data.

The time it takes to process data into PeMS should be decreased, or a program/interface upgrade should be developed for minimal cost to assist in processing the data to streamline and speed up this process. However, as Caltrans Headquarters manages PeMS, improvements to PeMS allowing for better integration of available count data into PeMS is outside of the control of the individual Caltrans Districts. Improving access to traffic data will require either Caltrans Headquarters to upgrade to PeMS to automatically download data available in TSN and make it faster or for a separate reporting system to be created to compile and allow for all of Shasta County to access data through a separate portal.



IV. SYSTEM EVALUATION AND FEASIBILITY

Within the industry, there are many different approaches to collecting, processing, reporting and disseminating data collected by field equipment. The tools are internal or external systems and vary in the type of information provided, accessible formats, and granularity. This section presents various tools that are utilized within the industry.

A. Data Collection System

There are many technologies available for collecting traffic data. The technologies presented in this section include innovative technologies as well as well-established technologies. Some of the real-time data collection applications are already utilized within Shasta County; others are emerging in the industry. Each application includes a discussion of the system architecture, data elements collected, validation processes, system performance, data analysis, and dissemination methods that should be considered.

Many of the technologies are able to provide several types of vehicle detection data. The following is a list of the various types of detection parameters that are considered in this evaluation:

- Presence – Whether or not an object is present.
- Volume – The number of vehicles passing a particular point.
- Vehicle Occupancy – The amount of time a vehicle remains in a detection zone.
- Speed – The instantaneous speed of a vehicle as it passes a detector.
- Classification – The type of vehicle classification (e.g., truck, car, motorcycle). Some technologies determine the length of a vehicle (radar, video) while others determine the number of axles a vehicle has (loops, magnetometers).
- Incident – Identification of an incident based on detected changes in traffic flow.
- Origin and Destination – Determination of where a vehicle enters and leaves the roadway network.

The basis for the cost estimates presented within each vehicle count technology discussion, except License Plate Readers, assumes construction costs for the installation of a mainline count station in one direction with two detector loops per lane for three lanes. The License Plate Reader costs account for covering six lanes of traffic (three in each direction), to capture vehicles into and out of the region at a gateway. Estimated operations and maintenance costs per detector location are presented. Costs also assume a new controller and cabinet, but the costs do not account for conduits or conductors for power and communication. The costs also do not include system integration costs or other necessary costs like metal beam guard rail to protect new device installations. In Section V: Plan Implementation of this document, all project considerations including capital improvement costs, cost of providing power, operations and maintenance, and project development will be presented and considered for potential projects.

A table summarizing the technologies below can be found in **Appendix B**. The table presents the major items to consider when choosing a technology that best fits the needs of SRTA and Caltrans. Low,



moderate, and high values represent the order of magnitude compared to other technologies. The following bullet points describe the bases accounted for in each category:

- Accuracy - The closeness of measured data to actual values.
- Calibration Difficulty – The ease of adjusting the technology so it accurately collects data.
- Maintenance Frequency – The frequency of which devices must be cleaned, recalibrated, or replaced due to general operations wear-and-tear.
- Verification Frequency – The frequency at which the data from a technology will have to be checked and validated to ensure data collected is accurate.
- Integration Difficulty – The difficulty to integrate the data collected by the technology into an existing data collection system. Technologies that have widespread use in industry, like those that interface with detector cards, are relatively quick to integrate due to established standards for use. Technologies that are currently deployed by other Caltrans Districts may allow for easier integration since interface tools could be shared with District 2. Other technologies, like ALPR and Bluetooth®, that are new tools for traffic data collection, will require integration of specialized software. This category takes into account the time and effort required to implement, operate, and maintain the technology as well as the data collected.
- Power Supply - Whether the devices require hardwired power or are able to utilize a solar power system.
- Estimated Lifespan – The expected useful life of field devices based on similar deployments, as well as information compiled from the Knowledge Resource Portal provided by the U.S. Department of Transportation Research and Innovative Technology Administration (RITA). RITA collects and provides project information for ITS deployments throughout the U.S.
- Expected Long-Term Viability – The expectation of the technology’s normal growth and development capabilities.
- Estimated Yearly Operations & Maintenance Costs – The estimated number of staff hours required each year to provide general maintenance, including any validation tasks to ensure quality data collection.

The majority of the technologies listed below will allow for count data to be seamlessly integrated with the existing traffic data collection process currently used by Caltrans District 2. The technologies available for counting and classifying vehicles have previously been detailed in the, “Update of Guidelines and Operating Procedures for the Traffic Volumes Program” report created by Cambridge Systematics. Though the Guidelines do not specifically enumerate accuracy requirements for traffic monitoring systems, they do indicate error rates of most (if not all) detection technologies are less than the errors that result from estimation calculations used in the AADT process. Therefore, the Guidelines do not directly eliminate any particular technology from usage. Instead, the Guidelines recommend that any detection technology must be evaluated based on the location conditions, since field conditions will change the accuracy of all devices site to site. Of the technologies below, Bluetooth, RFID tag readers, GPS based traffic data would not be conducive for traffic monitoring count stations because each vehicle that passes may not be equipped with appropriate sensors and thus unable to capture every vehicle for counting.



B. Technology Evaluation

1. INDUCTIVE DETECTOR LOOPS

Inductive detector loops have been the industry standard technology for detection since the 1960s and consist of a series of coiled loops placed in the roadway's surface to create an electromagnetic field around the wire. When a metallic object (e.g., vehicle, bicycle) passes through the electromagnetic field of the detector loop, a disturbance is caused in the field. The loops are connected to sensor cards enclosed in a nearby cabinet which are programmed to be triggered at a pre-set threshold. Speed is typically calculated by installing two (2) loops twenty feet apart, then measuring the time it takes a vehicle to travel between the loops. These readings can then be used for presence, passage, lane occupancy, and or speed measurements.



Since loop detector use is a very widespread and proven technology, loop detection systems are relatively easy to deploy and integrate. There are established standards that provide for quick implementation of a loop detector-based system that will provide highly accurate traffic data. Additionally, compared to some other detection systems, loop detection is not affected by weather and other environmental factors. However, loop detector installation does require saw cutting the roadway pavement surface, resulting in higher installation and maintenance impacts such as lane closure, traffic control, and decreased pavement life.

Costs

Loop detectors are the most common technology for vehicle detection, but some agencies do not have sufficient staff to maintain reliable loop performance. Construction installation cost of a single freeway detection station using inductive loops is approximately \$35,000 which includes the cost of installing the loops, a controller cabinet, a dial-up modem, and controller equipment. Integration and maintenance costs per station will not differ from what District 2 pays for their existing census stations. Currently, operations support is estimated to be 20 hours per year per location while maintenance is approximately 8 hours a year per location.

Feasibility

Inductive detector loops are the best and most conventional option to collect vehicle data. The technology is well-developed and has already been deployed throughout Shasta County and District 2. Existing non-permanent (i.e. counter is only on-site during data collection periods) stations already have in-pavement loops and could be upgraded to permanent stations (i.e. install cabinet and counter in order to collect data at all times) or Traffic Monitoring Stations (TMS). The use of detector loops can also be paired with statewide infrastructure since TMS stations with loops are most commonly used. Loop detectors are highly feasible to deploy.



This technology addresses the future potential need for a ramp metering system as well. Caltrans’ ramp metering guidelines assume the use of detector loops. These loops can replace the temporary count tubes currently used to monitor ramp volumes. In coordination with the current ramp volume monitoring system, detector loops are a feasible option for ramp metering implementation.

2. RADAR DETECTION

Radar detection is a non-intrusive technology that can be deployed for advance detection without impacting the pavement. Radar detection relies on microwave technology to detect, monitor, and measure vehicle traffic without installing equipment in the roadway. There are two types of microwave radars: continuous wave (CW) and frequency modulated continuous wave (FMCW). CW radars use the Doppler Effect to determine occupancy and speed. The radar transmits a continuous, low-energy wave that is constant in frequency with respect to time. When a vehicle passes through the detection zone and makes contact with the wave, it causes a shift in the frequency that is relayed back to the radar. This shift is captured by the radar’s sensors and can be used to determine vehicle occupancy and speed. CW radars require the vehicle to be in motion to be able to detect a change in frequency; therefore, stopped vehicles cannot be detected. FMCW radars emit waves that are constantly changing with respect to time. This method incorporates auxiliary range measuring capabilities and is therefore able to detect motion-less vehicles.

Though radar detection has mostly been deployed to monitor traffic at a single point along a roadway, manufacturers are producing radar detection systems that are intended to replace traditional inductive loop detectors. Radar detectors are mounted at fixed positions and can emit waves from overhead or side fire. A single unit can provide multi-lane coverage in one direction and has the capability to average vehicle speeds over several lanes, but is not suitable for lane-by-lane data. This type of sensor is generally resistant to inclement weather; however, some models do have issues in heavy fog or when installed on steel bridges. Additionally, high truck volumes can reduce the accuracy of the system due to occlusion.



This technology performs well for both low and high-volume counts and can be installed without lane closures or other traffic obstruction.

Costs

Construction costs are estimated to be near \$14,000 per station. Operations and maintenance costs would be greater than those estimated for TMS deploying loop technology because of the higher amount of support to verify the accuracy of the data collected. It would be reasonable to assume an additional 12 hours total of operations and maintenance support a year per location.



Feasibility

Radar detection is a feasible option for additional count stations in areas where data is desired and does not exist. They can be installed along I-5 at regular intervals and could transmit data to the TMC. This type of detector could also be used for on and off ramp volumes and replace the need to manually deploy tube counters to collect the data. Installation of this technology would not require any traffic-impacting construction as no roadway pavement work is needed. An upgrade to the District's central equipment and software would be necessary to deploy radar. The process of collecting the data and transferring it to PeMS would require a Front End Protocol Translator (FEPT), which the District does not currently have.

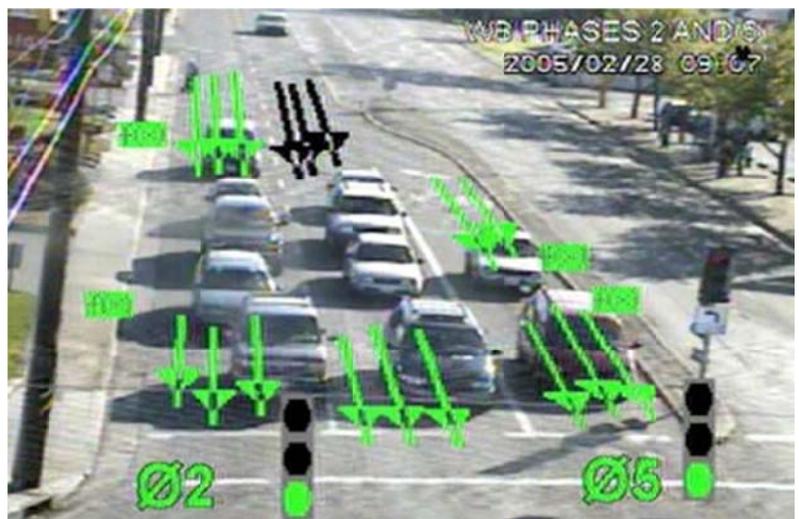
Stand-alone radar stations with solar power and cellular communication are a great option for detection locations far away from existing power and communication infrastructure. The feasibility of this option, however, would depend on site conditions and whether or not cellular connection is available at a specific location.

Since radar detectors are generally weather resistant, inclement winter weather would not affect them. However, since I-5 is a major route for truck movement, high truck volumes could interfere with the accuracy of detectors due to occlusion. Installation of radar detectors on overhead structures could be considered to minimize occlusion. However, overhead installation and maintenance of radar detectors would require lane closures. District 2 has deployed microwave detectors at two test sites on I-5 that were installed in the center median area to mitigate occlusion impacts, but these are not currently in use nor integrated into the existing system.

Radar detection has limited capabilities to detect classification. Although it is able to detect vehicle length and type, which is a form of vehicle classification, it does not automatically detect number of axles and thus does not fit all census statistics requirements.

3. VIDEO IMAGE DETECTION

Using fixed position video cameras mounted above traffic, a Video Image Processor (VIP) system analyzes video via algorithms to produce traffic data. Easy to modify and customize, user defined zones identify the areas where detection is to take place. A single camera connected to a VIP is capable of providing detection over multiple lanes, including separate detection zones in one lane. The VIP is capable of detecting vehicle presence, occupancy, vehicle speed, classification, bicycles, and traffic incidents. In addition, the video captured by the system can be used for traffic monitoring viewing by





City/County/Caltrans personnel. Since a VIP system is able to trigger phase selectors in the same manner as detector loops, the data provided by the VIP system should be relatively straightforward to integrate with Caltrans' existing data collection system.

While video detection systems are capable of providing a large amount of traffic data, there are factors that must be considered prior to installation to ensure a reliable system. First, environmental factors like rain, snow, night, shadows and dirt on the camera lens can degrade the performance of the system by degrading the quality of video captured. Because of the effect of environmental factors on video detection quality, Caltrans prefers not to deploy video detection at traffic signals. Additionally, if the camera is not installed in a place that provides optimal viewing of traffic, occlusion will prevent the system from seeing all vehicles passing through the detection zone.

Costs

The cost to install a stand-alone video detection station along a freeway to collect vehicle counts, classification, or speed is on the order of \$22,000. Costs could increase significantly if there is a desire to directly view the video due to the need for a high speed data connection, although future fiber optic cable installation along I-5 will help manage these costs. Caltrans currently has a standard workload of 16 hours per year per CCTV camera for Caltrans operations support and another 16 hours of preventative maintenance support. Video image detection cameras would require about the same preventative maintenance support as existing CCTV installations but the operations support would be higher since the system would need to be monitored for accuracy.

Feasibility

Video image detection is an option for filling in gaps where count stations are missing throughout the Shasta region. It is an effective non-intrusive technology that has the option to be a stand-alone system since it is capable of utilizing solar for power and cellular for communications (however, this option is dependent on good cellular service reception and direct sunlight). Construction of this type of detector would not typically require any lane closures.

For the Shasta region, video image detectors may lose reliability due to their susceptibility to weather-related technical problems. Snow and rain during the winter months can hinder the quality and accuracy of the detectors. Also, though they can detect vehicle classification, they cannot automatically detect the type of classification counts that fit the criteria that census statistics require (i.e., number of axles).

This technology should be considered as an option for traffic monitoring, but could be better suited for signalized intersections (which is not an objective of the stakeholders) rather than arterial freeways such as I-5.

4. AUTOMATIC LICENSE PLATE READERS

Automatic License Plate Readers (ALPR) uses Optical Character Recognition (OCR) to identify vehicles by their license plates. This type of technology has many applications including traffic data collection, toll collection, and law enforcement. This technology utilizes cameras that capture images using infrared for better clarity and image processing. Algorithms are used to take the captured image, digitize it, recognize



individual characters and translate them into ASCII characters. These characters can be stored in a database module and can be used for various applications.

ALPR cameras capture images in any environmental condition, day or night, and can be processed using real-time software or transmitted to a data center. They can capture images of vehicles with speeds up to 130 MPH with good accuracy, depending on the manufacturer and device model. For instance, Motorola's® ALPR provides 130 MPH capture speed with 90% accuracy. Cameras can be installed at fixed positions overhead or side fire, though caution must be taken to ensure proper angling of the camera for optimal reading. This technology can offer a non-intrusive, wireless method of traffic data collection, having the potential to measure occupancy, presence, travel time, and speed depending on the algorithms used. ALPR systems use proprietary software to digitize and translate images into characters, so integration with PeMS will require substantial effort.



Costs

Estimated installation costs for covering both directions of travel (six lanes) in order to capture all traffic in and out at a gateway is approximately \$63,000. Installation costs include central software and vendor construction support. Additional yearly licensing fees of approximately \$2,500 per gateway are anticipated. ALPR operations and maintenance costs would be very similar on a per camera basis as video image detection.

Feasibility

ALPR is a feasible option for collecting O&D data. Implementation of the infrastructure is non-intrusive and would cause little traffic impact. Though the technology has the ability to monitor various traffic characteristics, it would not be capable of replacing the need for conventional and more commonly used technology such as in-ground loops for accurate speed and occupancy. Furthermore, though ALPR can capture length-based vehicle classification, they are incapable of detecting number of axles, which is a criterion required for official census statistics.

Incliment weather may degrade the accuracy of the readers, and could potentially require a high amount of maintenance. Implementing an ALPR system is an expensive option due to the need for proprietary software to digitize and translate images into characters. Integration with TSN/PeMS will also require substantial effort. Though this is the case, an ALPR system is still feasible for the gateway locations as it is very reliable for O&D monitoring and the system can analyze O&D data.

5. MAGNETOMETERS

Magnetometers are devices that have the capability to count both vehicular and bicycle traffic, detect presence and speed, and in many models, can transmit data wirelessly through wireless radio frequency.



Magnetometers are small in size compared to traditional loop detectors, some models such as Sensys® 3-axis series being just 3x3x2 inches in dimension. Magnetometers can be installed in small saw-cuts or holes in the road surface and can also be installed underneath bridge structures. Magnetometers are installed in the same configuration as loop detectors, with one magnetometer per lane for volume counts or two per lane to capture vehicle speeds and volumes.

A magnetometer functions by detecting perturbation (magnetic anomalies) in the Earth's magnetic field. The device is first calibrated to the local environment and recorded as the base condition. When a vehicle drives over the device, its metal body distorts the Earth's magnetic field in either the x, y, or z axis as it enters and passes through the magnetometer's detection zone. As a vehicle enters this zone, the Earth's magnetic lines compress, converge, and then diverge as the vehicle exits. This perturbation of the Earth's magnetic field is captured by the magnetometer and recorded. This data is then sent to a main controller through wireless communication. Data collected is essentially the same as collected by loops; therefore, the data can be easily integrated into PeMS.

There are several advantages to magnetometer-based traffic data collection. For many models, installation requires the drilling of a small hole using a hammer or core drill, with fast-drying epoxy as sealant. This quick and simple installation means shorter lane closures and disruption of traffic. Magnetometers also have a long battery life, reported to last up to 10 years, and requires only a low amount of communication bandwidth transmit data back and forth. It is important to note that due to the fact that the technology is still relatively new, the overall battery life of the devices is still under evaluation.

Disadvantages to the magnetometer include its difficulty in detecting stopped vehicles since the detector requires a ferromagnetic object to perturb the Earth's magnetic field, which is done only when it is moving through the detection zone. Some models also have small detection zones and thus require multiple units to be installed to be able to capture wide roadways. Communication between the sensor and the control unit can pose problems at times due to the use of the low power ZigBee standard often used with this type of technology. Instances of jammed connections are not uncommon, causing data to not be received and stored by the central server. Lastly, the batteries in the detectors are considered hazardous materials and require special removal measures whenever the detectors are replaced at the end of their life.

Costs

Magnetometers are in the moderate price range, with installation costs at approximately \$21,500 per location. Caltrans District 4 is currently deploying magnetometers at select detector stations, so integration efforts in District 2 may be low if there is an interface already in place that can be utilized. Due to sensor battery life, the magnetometers may need to be replaced at least every 10 years, and battery life may be shorter than that. Based on that alone, maintenance costs for magnetometers are going to be higher than loops since magnetometer life cycles are shorter and will need to be replaced more often.

Feasibility

Magnetometers are an option for the installation of new count stations at desirable locations within the County. This technology can replace non-permanent loop locations or any loops that are no longer functional. They are easy to install and would require minimal lane closures and disruption of traffic. Because magnetometers are currently used by other Caltrans districts, integration to Caltrans' current infrastructure may not be as intensive. This technology can be installed on mainlines as well as on and off



ramps for volume monitoring. Furthermore, magnetometers can be paired with a system that communicates directly with the TMC and would require low communication bandwidth to transfer data.

Since magnetometers cannot detect stopped vehicles, they may have trouble detecting vehicle presence during inclement weather in winter months. Vehicles stopped along I-5 would not be captured by the magnetometers. Stopped vehicles on ramps may also not be detected; therefore, this technology may not be feasible for use with a ramp metering system. Magnetometers are also incapable of detecting any form of vehicle classification.

Overall, magnetometers are a good option for the District to consider. Moderately priced and easy to install, this technology is comparable to inductive detector loops and can have many applications for Shasta County.

6. ACOUSTAL DETECTION

Acoustic vehicle detection technology is a passive, fixed-unit detection method for traffic data collection. This technology is able to collect traffic counts, detect presence, speed, and occupancy (but not classification) using a two-dimensional array of microphones to detect the acoustic energy produced by a vehicle's tires as they drive over pavement. When a vehicle drives through the sensor's detection zone, sound is picked up by the microphones and triggers a sensor. When the vehicle drives out of the detection zone, the audible levels drop below a specific threshold and the signal to the sensors are terminated. The sensor only focuses in on the specific detection zone; all other sounds are filtered out and are unaccounted for. Vehicle speed is detected by setting two detection zones and assuming an average vehicle length.

Acoustic sensors offer advantages that include ease of installation and low power consumption. The latter makes acoustic technology suitable for solar power operation. Acoustic sensors are non-intrusive and can be installed in a short amount of time without lane closures. They require low to moderate communication bandwidth and can be connected to existing traffic controllers. Because acoustic sensors pick up the sound generated from tires moving on pavement, this type of detection technology does not work well with slow moving vehicles in heavy traffic. Furthermore, though the sensors are resistant to precipitation, it has been found that the accuracy is affected if subjected to cold temperatures.

Costs

There are two acoustic sensor models that are currently used: SmartSonic® and SAS-1® sensors. Costs associated with acoustic technology range from \$14,000-\$20,000 for the purchase and installation of sensors, depending on the number of lanes that require detection. One acoustic sensor either mounted roadside or over traffic may provide detection for up to five lanes of traffic in one direction of traffic. Operations and maintenance activities are likely much higher than any other detector technologies due to acoustical detection's questionable reliability, and higher data verification support.

Feasibility

Acoustical detection is a technology that can address the need to install more permanent count stations at regular intervals. Paired with communication to a TMC, this technology would be useful and would require low bandwidth. The downside to this technology is its high maintenance requirements and its



difficulty in detecting slow moving vehicles. During winter months, when vehicles may be traveling slowly along I-5 during inclement weather, the detectors will not be able to capture their presence as the vehicles may not be making enough sound due to their slow travel speeds.

This technology is not extensively used throughout the industry. Reliability is questionable, and integration with current infrastructure may be difficult.

7. BLUETOOTH

The Bluetooth protocol is a widely used, open standard, wireless (2.4 GHz ISM radio band) technology for exchanging data over short distances but is a new application to the traffic data collection industry. The technology is frequently embedded in mobile telephones, Global Positioning Systems (GPS), computers, and in-vehicle applications such as navigation systems. Each Bluetooth device uses a unique electronic identifier known as a Media Access Control (MAC) address. Conceptually, as a Bluetooth equipped device travels along a roadway, it can be anonymously detected at multiple points where the MAC address, time of detection, and location are scanned and logged. One application for Bluetooth is to derive actual travel times between two points. By determining the difference in detection time of a particular MAC address at two or more points, the travel time between those points can be derived. Installing a network of Bluetooth devices could provide the ability to collect origin-destination data for travel demand modeling, real-time travel time traveler information, and for evaluating system wide performance measures.

The use of Bluetooth MAC addresses for travel time monitoring typically only requires one inconspicuous roadside installation to capture the unique address of Bluetooth devices traveling in all directions of flow, with an approximate detection range of 300 feet. In some cases, Bluetooth has been viewed favorably because of its low capital costs and accuracy compared to other travel time detection methods, but it is critical to have a sufficient sample size for reliable data. Some Bluetooth applications have been known to only capture 5-7% of traffic, which is not sufficient for a reliable data point. Other applications have reported 15-20% which is a reasonable sample size for travel time and origin-destination calculations.

Costs

Typical installations of this technology cost approximately \$1,500-\$2,000 per location, which includes only the equipment and installation costs. A new pole and foundation for mounting the equipment will be required. Recurring licensing fees and yearly data validation costs will also be required. With these integration and implementation costs considered, Bluetooth detection can total up to \$8,000 to \$10,000 per location. Maintenance and operation costs are estimated to be similar to radar detection.

Feasibility

This technology is a possible option for collecting O&D data. It is capable of providing travel time information and would be cheaper than other non-intrusive options; however, it would not be the most viable option for Shasta County because the SCUR may not have the vehicle volume to support this type of data collection method. Moreover, with cellular device manufacturers decreasing the amount of time a phone is left in "discoverable mode", some Bluetooth detectors will not be able to capture an acceptable sample size.



Bluetooth technology is constantly being developed to improve detection ranges and reliable coverage. As technology improves in the future, Bluetooth may be a feasible solution for O&D data at gateway locations.

8. RADIO FREQUENCY IDENTIFICATION (RFID) TAG READERS

RFID technology can be used as a wireless and non-intrusive method for traffic data collection. The use of RFID for traffic data requires two main elements: the transponder and the tag reader. The transponder contains a RFID chip embedded with an electromagnetic field coil that is used to transfer information to the tag reader. This system is widely used for commercial vehicle operations and electronic toll collection (ETC) such as FasTrak® in the Bay Area. When a vehicle passes through the detection point, the tag reader communicates with the transponder inside the vehicle through radio frequency and collects the data (e.g., vehicle permits, tolls). For traffic data collection, tag readers can be strategically placed throughout a corridor to collect vehicle counts and occupancy. Since each transponder has a unique identification code, vehicle speed can be detected by setting tag readers at certain intervals to capture and encrypt the vehicle's transponder ID at these check points.

The effectiveness of this method for traffic monitoring relies on vehicles being equipped with the transponders and a high enough sample size to be representative of all traffic. In some instances, not all transponders may be read by the tag reader or can be misread. Commercial vehicles often have RFID tags, but truck speed is not a good representation of general traffic flow. Implementation of RFID technology will require proper placement and field testing of tag readers to ensure optimal communication between the reader and the transponder.

Costs

An estimated cost per toll tag reader location is approximately \$13,000-\$17,000. Installation costs assume that readers would be placed on existing overhead sign structures. Operations and maintenance costs would be very similar to radar detection.

Feasibility

RFID tag readers are another option that could collect O&D data. This technology is known to provide reliable travel time information between two points, but needs a large sample size to be considered reliable. In this manner, RFID tag readers cannot successfully capture volume, speed, or occupancy in real-time, as the sample sizes do not reflect traffic conditions as whole. The chance of error is high with this technology as the tag readers must read the same transponder at two locations, presenting a high likelihood of misreading a transponder or not being able to read one at all. It relies on vehicles to be equipped with a transponder, adding another logistical step before data collection can begin. There is no system in the Shasta region that utilizes RFID tag readers so vehicular volume may be too small to provide an adequate sample size. Additionally, integration and implementation costs would be too high for a technology that has questionable reliability and performance. In the SCUR, it is unlikely that there is a large enough sample size for this technology to be a feasible solution.

9. GPS BASED TRAFFIC DATA

There are private companies that collect and offer traffic data for purchase. Companies such as TomTom® utilize their Global Positioning System (GPS) navigation devices to collect data that serves as the



backbone for real-time and historical traffic services. GPS devices have the capability of storing specific vehicle data such as travel speeds, which roads it has traveled on, and where it experienced congestion or slowdowns. A user can allow the device to share this data and therefore give permission for data to be extracted via GPS connection. This aggregate data is used to create traffic data services that planning agencies may find useful.

Companies like TomTom® have built extensive databases through GPS data collection along with traditional sources such as field surveys and aerial/satellite imagery. Their methodology enables them to create robust web-based applications that offer accurate real-time traffic information, traffic flow prediction, travel time predictions, and speed profiles. Planning agencies can pay to use these applications to enhance their own existing data that is made available to the public and/or use the data for purely internal planning purposes. Agencies can use the information to know which areas are prone to congestion, high vehicle speeds, or the most popular routes being taken by travelers.



The use of private traffic data services can be a good supplement to a planning agency's existing traffic information system. It offers dynamic data that reflects a very large sample pool (for TomTom®, over 3 billion people globally) that can be implemented in various ways. Important to note, however, is that for privacy reasons, information is not given as raw data. Planning agencies must use the private company's web-based applications to query the information of interest through search functions, and the data will be output accordingly. Since the raw data is not provided to the agencies, direct integration with the existing data collection system is highly unlikely. This data would need to be obtained from TomTom®.

Costs

Costs associated with implementing GPS-based traffic data services are on a case-by-case basis and can differ vastly. Costs are mainly attributed to system implementation/integration costs and recurring data purchasing costs. If this data is intended to be utilized for real-time operations then an agency must also consider the costs required to implement the new data source into their existing operational environment and must understand the limitations of the data that is available. The recurring cost to obtain the data will typically be paid on a monthly basis and the cost level will vary based upon the quality of the data provided and the number of lane miles to be captured.

Feasibility

GPS-based traffic data is an option for collecting O&D and travel time data. It is a viable option for performance monitoring of other real-time infrastructure since data captured through GPS represents true movement of a particular vehicle. This vehicle's data can be compared to travel time predictions formulated by real-time infrastructure elements. Though GPS data can provide useful information, the technology can have reliability and performance issues due to a low sample size of data and access to GPS in mountainous regions. Though this technology does not require any new infrastructure, planning agencies would incur an ongoing fee from a private traffic data service provider that process the data. Raw data is not provided to agencies and can only be used through the private party's software. GPS data is unable to provide vehicle volume data and it is only able to provide average roadway travel speed data.



Though GPS traffic data is an option for collecting O&D and other data, it is not a feasible option for Shasta County at this time due to the limited sample size. Due to the nature of the data source (only from users with GPS onboard the vehicle), GPS traffic data is unable to provide volume data. Also, while GPS traffic data is able to provide roadway speed data, the speeds are an average over a segment of roadway and not on a per vehicle basis.

10. COMMUNICATIONS INFRASTRUCTURE

The current data collection process is tailored to the federal standards and requirements for collecting census data. The infrastructure provides the ability, albeit manually, to collect the required data for the federal program. Since the infrastructure was configured to this purpose, there is very little opportunity to reconfigure field equipment to provide additional functionality without investing in additional communications equipment and other permanent field equipment. There is no opportunity to provide origin-destination data with the current equipment. With the addition of permanent communications equipment there is a significant opportunity to utilize existing infrastructure for enhanced data collection purposes.

To support the implementation of new technology that will enhance the District's data collection processing and procedures, upgrades to the existing communication infrastructure is necessary. Upgraded communication lines to bring information from the field to the TMC will enhance the capabilities of the District to make traffic data more readily available. Additionally, improved communication infrastructure would allow for reduced field collection hours for Census staff that can otherwise be used for data analysis and other transportation management tasks.

A potential optimization for the District's current system is to provide direct network communication to permanent detection stations. Currently, communicating with permanent detection stations is through a manual dial-up connection. This process could be enhanced by providing a direct network communication link to the counters, enabling users to get binned data as it is stored and refresh the binned data at any desired interval.

With a direct communication link a modem connection is added to a communication network and it is not dropped. Fiber, copper, wireless and certain types of telephone or cellular communications can provide this permanent network connection. A network connection could be established with the counters through a terminal server. This terminal server creates a network connection through the counter's RS232 port. This terminal server is a small set-top device that could be placed adjacent to the counter in the cabinet. The Diamond Phoenix counter can be retrofitted with a second high speed serial port to aid in this type of communication.

Fiber and copper infrastructure are the most reliable mediums for communications networks, but it is also the most expensive due to the cost of installing conduit and pull boxes. Construction costs can occasionally be reduced by including the work as part of other roadway projects if budget is available; however, end equipment would still be required for all field equipment.

Another cost effective way to establish a network connection would be either through a telephone or cellular network. A cellular solution can be more cost effective in comparison to telephone; especially if



there is limited telephone utility infrastructure nearby. A cellular network can be established as an enterprise solution through any commercial carrier. In Caltrans District 7, a private cellular network from AT&T is used for some network communications to ITS equipment. Since some of the existing Census stations in Shasta County already utilize a cellular modem, this might be an attainable next step at those locations.

Feasibility

Caltrans District 2 currently utilizes Plain Old Telephone Service (POTS) and cellular modems to communicate to existing census stations. POTS is the most cost effective communication method since Caltrans only has to pay for actually time used instead being charged a monthly usage fee. Caltrans also utilizes a special Calnet II rate which might be a feasible network solution.

Caltrans District 2 is in the process of establishing a licensed microwave wireless network for communications to closed circuit television (CCTV) cameras throughout the region. New vehicle detection stations may be able to utilize this same system if installed close to existing CCTV cameras. To make this connection, a direct connection between the detector station and CCTV camera station would need to be installed and then integrated into the wireless system equipment at the CCTV camera station.

Lastly, a fiber optic trunk line is currently being installed through the I-5 widening project. This will provide a communication backbone for connecting new and existing vehicle detection stations along I-5. This fiber optic network is anticipated to be completed within the next two to three years. Fiber or copper communications is not feasible along other routes in the network due to the high costs of installing conduit and possible right-of-way acquisition.

A hybrid approach of providing communications to low bandwidth roadside elements (like TMS and permanent count stations) may be a very cost effective option. Under this scenario, communication nodes/hubs would be established along the proposed I-5 fiber backbone. The nodes would provide a high-speed network connection back to the TMC. CCTV cameras, CMS and other critical elements will be directly connected to these ITS Nodes and hence, the fiber infrastructure. The less critical elements (like the Traffic Monitoring Stations) would be connected to a node by a "linear mesh" wireless network established from TMS to TMS along I-5. Each ITS node would then provide an access point for the wireless system to connect to the fiber infrastructure and then the TMC. Utilizing nodes/hubs and a wireless network would help minimize costly construction costs required by physical communication infrastructure improvements.

Caltrans District 2's current preference for integrating devices into their network is to ensure that all new devices are compatible with an IP-addressable Field Element Network. All new vehicle detection stations will be initially deployed using general packet radio systems (GPRS) to establish communications. As Caltrans expands the fiber backbone and microwave network, the new count stations will be converted from GPRS to the hybrid communication approach described above.

C. Other Implementation Considerations

In addition to technology considerations, there are implementation considerations that need to be evaluated and discussed when deciding on a specific technology. These factors will have at least as much



impact on the selection of the best technology for the region because there could be significant cost implications that are independent of the technology that could require substantial construction budget or dictate feasible technology.

1. END USE OF REAL-TIME DATA

While much of the raw data collected by the technologies described in the section above may be used directly as-is by SRTA, cities, or Caltrans, the decision on which technology(ies) is most appropriate largely depends on how the data will be used. Volume, speed, and occupancy can be collected from most of the technologies presented here; but, the data may also be further analyzed to provide enhanced benefit to travelers and other public agencies. Many of the technologies are able to provide classification information, but the manner in which the technologies classify may differ. Technologies like radar and video can provide vehicle length information for classification use. However, this type of classification is not applicable for federal census classification that requires classification to be reported by number of axles. Volume counts and vehicle speed data may be used in ramp metering applications for developing ramp metering rates. Origin-Destination data can be used to determine travel time information that can then be integrated into traveler information websites like 511.

2. EXISTING POWER COMMUNICATIONS INFRASTRUCTURE

The factor with greatest potential effect on cost is providing power and communication to detector stations due to the installation of conduits and cabling in areas where there is no infrastructure nearby power or communication service. Installation costs per 1,000 linear feet of conduit may cost \$35,000-\$80,000, greatly escalating the overall cost per detector station and making a particular solution cost prohibitive.

To mitigate costs of remote detector installations, use of technologies with low power requirements, like those with a single sensor mounted on a pole on the side of the road (radar, video detection, ALPR, microwave), are able to rely on solar power will be the most cost effective. Additionally, these remote locations may be able to use general packet radio system (GPRS) wireless modems for communication. These modems utilize wireless phone connections to transmit data back to a central server system. GPRS is widely used by Caltrans throughout the state. However, when choosing locations of isolated detector stations with solar power and GPRS, the sites must be thoroughly examined to ensure that the location receives the adequate sunlight and cellular service to provide power and communication.

Estimated costs for various power and communication alternatives are presented in **Tables 1, 2, and 3** below.

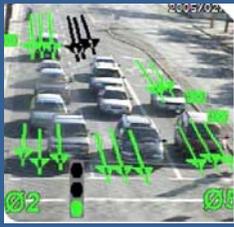


Table 1: Estimate of Probable Operations and Maintenance Costs for Hardwire Power (Per Location)

Element	Installation Costs (Per Location)		Recurring Costs (Per Location)						
	Conductors and Conduit ¹	Service Pedestal	Watts	Kwatts	Hours used per day	Days/Year	Total Hours/Year	Cost/KWH (cents)	Estimated Annual Electricity Cost
TMS	\$16,250	\$3,500	1000	1	24	365	8760	\$0.16	\$1,402
Permanent Station			100	0.1	24	365	8760	\$0.16	\$140
Radar			50	0.05	24	365	8760	\$0.16	\$70
Magnetometer			30	0.03	24	365	8760	\$0.16	\$42
Video Detection			30	0.03	24	365	8760	\$0.16	\$42
Acoustic			30	0.03	24	365	8760	\$0.16	\$42
ALPR (Assumes 3 camera system)			250	0.25	24	365	8760	\$0.16	\$350
Bluetooth			50	0.05	24	365	8760	\$0.16	\$70

¹ Assumes 250 feet of conduit between service point and service pedestal.

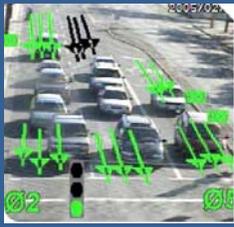


Table 2: Estimate of Probable Operations and Maintenance Costs for Solar Power (Per Location)

Element	Installation Costs	Recurring Costs
	Solar Panels and Batteries	Battery Replacement ³ (Annualized)
TMS ²	Not Feasible	
Permanent Station (Assumes 2 batteries)	\$6,500	\$300
Radar (Assumes 1 battery)	\$4,000	\$150
Magnetometer (Assumes 1 battery)	\$4,000	\$150
Video Detection (Assumes 1 battery)	\$4,000	\$150
Acoustic (Assumes 1 battery)	\$4,000	\$150
ALPR (Assumes 3 batteries)	\$6,500	\$450
Bluetooth (Assumes 1 battery)	\$4,000	\$150

² Due to high power requirements, solar panels are not an effective option for TMS power.

³ Assumes annualized cost of replacing batteries once every three years at a cost of \$450 per battery.

Expected lifecycle of permanent stations, radar, and magnetometers is 15 years. All other technologies are assumed to have 10 year lifecycles.

Table 3: Estimate of Probable Communication Costs

Sub-Elements	Quantity	Unit Cost	Total Estimated Installation Costs (Per Location)
Plain Old Telephone Service⁴			
Conduit and Conductors (ft)	250	\$50	\$12,500
Dial-Up Modem	1	\$1,000	\$1,000
Sub-Total			\$13,500
Microwave Wireless			
Antenna	1	\$2,500	\$2,500
Modem	1	\$2,000	\$2,000
Sub-Total			\$4,500
GPRS⁵			
Modem Assembly (With Antenna)	1	\$2,500	\$2,500
Sub-Total			\$2,500

⁴ Assumes \$20/month AT&T phone service. Data cost based on input from District 2 Staff

⁵ GPRS will incur a monthly service cost of approximately \$50



3. DETECTION LOCATION AND SPACING PER DATA TYPE

The placement and density of the detector stations heavily relies on how the data will be used. For origin and destination data, detector stations must be placed at all key entrances and exits of the transportation system. Traveler information systems require a large number of sensors to provide detailed and useful information like segment speeds and congestion. To deploy ramp metering along a corridor, detector stations will need to be placed at all on ramps and off ramps as well as at least one station on the mainline freeway between on and off ramps.

4. CONSTRUCTION IMPACTS ON TRAFFIC

The installation of detectors in pavement (e.g., inductive loop detectors or magnetometers) will require lane closures that will impact traffic. There may be instances where lane closures are not allowed or the costs outweigh the benefits. Non-intrusive detection will have lower impacts to traffic if they are able to be placed on the side of the roadway, but could have reduced accuracy due to weather conditions or occlusion. Non-intrusive detection that must be placed overhead would require lane closures.

5. LIFECYCLE AND RECURRING COSTS

With agencies being required to maintain existing infrastructure and systems with less and less staff, maintenance and replacement costs are major factors in planning and supporting the deployment of equipment to ensure system functionality. Ongoing costs, such as power and leased-line communications, will be applicable to the vast majority of technologies. Power costs may not be applicable to stand-alone detector stations that can utilize solar power; however, those stations will most likely rely upon GPRS which will require monthly cellular data plans.

Certain technologies will require regular maintenance to keep the devices at full operational capabilities. Video detection and ALPR cameras require yearly maintenance to clean the lens and to recalibrate the programmed detection zones. Inductive loop detectors have often needed to be replaced within 5 years due to roadway degradation, but Caltrans District 2 installs deep loops (2-4" depth) and generally the loops last for the life of the pavement.

All technologies require periodic calibration and verification activities to ensure data accuracy, some technologies more than others. This will require Caltrans staff to field verify the validity of the data and adjust the devices/programming to fix any inconsistencies. Particular technologies like loop detectors and magnetometers have been shown to be very accurate with little or no concern with the legitimacy of the data. Acoustic detection has been seen to be more prone to data degradation over time requiring yearly calibration checks. Factors such as weather and occlusion may require more frequent calibration and verification.

D. Data Processing

Once the data is transmitted back to a central system, there are enhancements required in order to process and report the data more frequently. For the District's data processing system, there may be an



opportunity to improve the procedures to deliver the data to TSN. There is currently no standard time frame at which data is transferred from TSN to PeMS. This varied time frame affects the efficiency of SRTA and other agencies because of the inconsistency of when data is available for analysis. PeMS is a powerful tool controlled by Headquarters, and an improvement on its existing data processing procedures would be beneficial for District 2, and for all Caltrans districts. If automated updating of census data on PeMS were to be made available, many of the timeliness concerns of data access from SRTA and Caltrans planning would be satisfied.

Another opportunity for optimizing the existing process is for the Census Team to provide data to SRTA at the same time as it is sent to be posted on TSN. The census data at this point of the process has been verified and reviewed by District staff. With some investment, SRTA and the District could also develop a parallel data collection system to process and report data more frequently and in specific formats. In a discussion with Nick Compin (Caltrans Headquarters Census Program Chief) and Jane Berner (Caltrans Headquarters PeMS Chief) on August 28, 2012, they indicated that there are no Caltrans policies that prevent individual districts from distributing the data or creating a separate system to process and report the data.

To mitigate the issue of a lengthy data processing and reporting time, changes in the PeMS system can be made to optimize the process. PeMS is currently a robust data reporting tool that can output large amounts of data in a variety of reporting formats. However, there are currently institutional problems that are prohibiting data to be posted to PeMS in a time frame that would be most beneficial to the District's planning and operational agencies. Data is submitted by the District to Headquarters for posting to TSN. The speed of this process and its final posting to TSN has been improved, with the District's Census Coordinator stating that it can take as little as just a day now for data to be posted. It is when the data is in TSN that it must wait a varied amount of time to be posted to PeMS. If this time can be shortened to an amount that is documented and made a requirement, the process would be optimized and processing and reporting of data would be improved. As mentioned above, PeMS is a powerful tool for data analysis; however, use of the system does require a certain level of familiarity and training to be able to utilize the system in an effective manner. Even if data is available, SRTA does not currently have the necessary training to be able to employ PeMS in a manner that maximizes its potential uses to fit their needs.

Enhanced central tools will equip Caltrans and other users with the ability to access data more frequently, proactively monitor traffic conditions, and export data for other uses.

Feasibility

The most desired option for the District is to optimize the Headquarters review and verification process to minimize the time frame at which data is transferred from TSN to PeMS. Specifically for the District, it would be helpful for census data to be posted as it is made available in TSN or at least on a monthly basis. PeMS is already a powerful tool for the District and may not need to be complimented or replaced with another data management system. This option would require no new system upgrades and very little effort by District 2. However, this option is fully dependent on Headquarters' staff to accomplish and the timeframe and effort for these improvements are outside of the control of Caltrans District 2. Also, a shortened time frame would require an effort by Headquarters to quality check the data in TSN at more frequent intervals so that the data can be pushed to PeMS faster. Such effort would require the proper staff and the available time for them to complete the task. Whether or not TSN/PeMS data integration is



improved, training for SRTA staff is required to familiarize them with the PeMS abilities and functions that may facilitate their traffic data collection needs.

Per Jane Berner (Caltrans Headquarters PeMS Chief), a project is anticipated for allowing automatic transfer of traffic data from TSN to PeMS; however no implementation schedule has been determined as of this time. If this projected is not anticipated in the near future, SRTA and District 2 should partner to further investigate the implementation of new procedures and software to maximize data processing capabilities and upgrade reporting tools. This would include evaluating a new tool for data processing and dissemination that would provide more timely data transfer to stakeholders external to Caltrans.

There is a number of third-party software that can achieve this, such as IBM's ITS Traffic Management System or MS2's Transportation Data Management System. Additionally, detection vendors, such as Wavetronix, offer off-the-shelf software capable of compiling, processing and reporting vehicle count data. Certain off-the-shelf software are designed to be modular in nature and the vendors report that their software has the capability to integrate data outputs from multiple data collection devices (radar, loops, etc.). An off-the-shelf option like this may require less integration effort and costs compared to implementing a custom system making it a viable option if a secondary data processing system is to be implemented.

A possible downside of implementing a processing and reporting tool that can make data available to users without the use of PeMS is the possibility of compromised data integrity. A separate system would bypass the full data validation processed used by PeMS prior to making the data available. Decreasing that time by processing and reporting the data outside of PeMS would make data available much sooner, but data reliability may decrease. Data should either only be made accessible to the new system once it has been processed by the Caltrans District 2 Census group or be updated/ revised in the system as validated data is made available. All in all, it is likely more feasible, both in terms of effort and cost, for the District to encourage Caltrans Headquarters to focus on improving the existing PeMS system than to implement new reporting tools that would accomplish the same goal. A separate quality control process may be required to verify information input into a secondary processing and reporting tool.

An upgrade to the District's data archiving system would require a robust data server that could handle a large amount of storage. If National ITS Architecture standards are followed and data is archived at the finest granularity, properly sized server infrastructure will be needed. The creation of a tool for data processing and dissemination would need to have a thorough database of detailed historic data. A challenge with this solution is which operations or planning group would be responsible for the operation and maintenance of the system and database. The development of an agreement would distinguish clear lines of responsibilities and benefits.

E. Data Reporting

New software could be developed and implemented to optimize the data reporting process. A central system can be accessed by multiple entities for data requests to help enhance transportation planning activities. This program could be used to validate the data, automatically format data for PeMS, or integrate the data into a non-PeMS portal or system that could store and disseminate the data on a more



frequent basis so it could be used by District 2 and other agencies. As mentioned above, a software tool like that offered by Wavetronix would have the ability to compile, sort, and distribute data in a user friendly fashion.

Instead of the expense of a full software program, a variant of this optimization could be the use of macro-scripting often used in database programs such as Excel, Access, MySQL, Lotus or Oracle. Utilizing database scripting can provide more customization of records and field information but may be limited to file sizes smaller than what the District works with. This could be overcome by either reducing the granularity of data collected or parsing the files into workable segments.

Implementation of useful reporting tools will require a robust archiving system that can process the required data. A key factor is to implement a system that archives data at the finest granularity to ensure that it can encompass a wide variety of uses. Archiving systems must be kept up to date with current technology and should be capable of archiving new traffic parameters that may be implemented in the future. For instance, the system must be capable of storing information fed by current permanent count stations through manual polling over a modem connection, and be able to quickly adapt and archive data from upgraded technology to avoid a gap in historic data availability.

In the future when recurring congestion is present, providing traveler information will help drivers make the best possible traveling decisions. Development of a real-time traffic and incident monitoring tool can also provide traffic conditions to TMC operators. Using real-time and historical volume, speed, and occupancy data, a central system can alert TMC operators or drivers when a certain pre-determined threshold is met. This alert system can be integrated into vehicle detection stations to automatically call a flasher or changeable message sign, contact the TMC, or push alert messages to travelers.

1. THIRD PARTY CENTRAL SYSTEMS AND DATA AGGREGATORS

Various companies have developed central systems that compile, translate, and aggregate field data. Some companies provide services to develop custom systems tailored to the needs of the clients. Other systems may have data collection software that is intended to compile data from field devices and compile the data for reporting. The data collection software is generally compatible with a number of different detection devices and translates the data into a usable format. Users can then access the data and make custom data reports to export the data.

There are numerous providers of third-party traffic data. While each company creates traffic data from a variety of sources, differences lay in data fusion techniques. Data fusion is a method of combining different sources of traffic data with weight to factor in the variables to data quality such as reliability, density, latency, data point frequency, and traffic volume. Each of these solutions is a proprietary methodology to determine the best quality of data. While some data source details and methodology are available, most have not publicly shared this knowledge. Some companies have clearly identified themselves as resellers of data and can be contacted for purchase of selected segments of information. Others maintain proprietary data.



The following are examples of third party data that is available:

Sigalert.com – A “SigAlert” is a popular term to many living in urbanized areas of California. The term, dating back to a radio operator in the 1950’s, is used by CHP and the media to identify “any unplanned event that causes the closing of one lane of traffic for 30 minutes or more.” These are issued by the CHP and Caltrans who will sometimes use the term to “identify any major traffic incident that will tie up two or more lanes of a freeway for two or more hours.”

The website features maps illustrating congestion, speeds, and camera icons in some areas of the state. There is no data provided for Shasta County with the exception of some camera images. The data is provided to Caltrans, but does not support the needs of SRTA.

Sigalert is owned by Clear Channel Communication and will provide free and subscription versions of Sigalert data to website visitors. The traffic data that Clear Channel utilizes is through their brand called Total Traffic Network. Total Traffic Network owns their own network of reporters, traffic cameras, aircraft, infrastructure, and other partners to verify and produce traffic information. Clear Channel does sell their raw traffic data to numerous personal navigation device manufacturers and automakers but have not indicated publicly that they sell directly to government agencies.

Total Traffic Network data is tested for accuracy against a ground-truth testing methodology called Floating Car Data Quality. In this approach, the ground-truth detection is executed with probe vehicles, utilizing a statistical test to indicate when collected drive data is sufficient for a desired level of confidence.

Google – Traffic is a feature added to Google Maps in 2007. This tool is primarily used on computers and smart phones to view real-time congestion information. Real-time travel time data is also provided when directions are queried. The congestion map display is the primary user interface, which illustrates green-yellow-red congestion levels. This data is primarily focused on providing information to drivers; professional use of the data is not a major component.

Google’s data primarily comes from Android Google Map subscribers that have agreed to share their mobile device GPS probe data, known as “crowdsourcing”. Accuracy of crowdsourcing road congestion data is reliant upon the number of probes in the vicinity and may be limited in accuracy depending on the frequency and number of data points. Accuracy information is not provided by Google.

Google has not publically indicated that they sell their traffic data, but the data can be integrated into others systems for a fee. Google Maps traffic data is a source for travel speed information displayed on Caltrans’ QuickMap, but does not meet the needs of SRTA.

INRIX – INRIX is a private traffic company that specializes in traffic data collection via data probes and data fusion, real-time information diffusion and traffic data prediction, and is a major provider of traffic and routing data to a variety of third-party users. INRIX focuses on “flow” type maps but also emphasizes routing, travel time and prediction. Data is derived mostly from probe data which means vehicle speed is the primary data available. Predictive vehicle data and historical data are also available for transportation planning and modeling.



Data is primarily provided to third party automotive manufacturers or navigation system manufacturers, but is also now available through smartphone apps (free subscription) to the public. Corporate or public sector clients can purchase data for transportation management or planning.

A number of public agencies have utilized INRIX traffic data for tasks ranging from travel time information, roadway performance measures, and congestion monitoring. INRIX customers include or have included New Hampshire DOT, Massachusetts DOT, Missouri DOT, and Georgia DOT. The San Francisco Bay Area's MTC is in the process of executing an agreement to purchase INRIX data to be integrated into 511.

In-Vehicle Navigation Systems – In-vehicle navigation systems leverage in-vehicle devices as probes. In-vehicle navigation systems provide dynamic routing and travel time information for subscribers. This data is updated approximately every two minutes.

Like other data fusion traffic providers, these navigation systems have multiple data sources, such as cellular floating car data (CFCD), which is a timing advance measurement to triangulate position. It also uses GPS based probe vehicle data. Like Clear Channel, this data is typically ground-truth tested for accuracy.

SpeedInfo – Founded in 2002 in San Jose, SpeedInfo specializes in the deployment of solar-powered Doppler radar sensors in addition to server software and a dedicated network. SpeedInfo customers include mass media organizations that provide traffic information that radio and television networks broadcast to consumers, traffic aggregation companies, and mobile application developers, such as content providers for automotive navigation systems. Only speed data is offered by this source at this time.

SpeedInfo is currently deployed by various DOTs and MPOs throughout the country. Caltrans, the Metropolitan Transportation Commission in the San Francisco Bay Area, and the North Carolina Department of Transportation utilizes SpeedInfo data for 511 traffic and traveler information. Other agencies that use SpeedInfo include Washington, D.C. DOT, Ohio DOT, Colorado DOT, and Hawaii DOT.

TrafficCast – TrafficCast provides travel time forecasting and traffic information using traffic flow theory and probe data technologies, as well as mobile services, digital content and media marketing. TrafficCast claims to have developed the largest traffic data platform in the industry referencing historical and real-time traffic for over 450,000 miles of roadways in the United States. TrafficCast analyzes real-time data from expressways and major arterials as well as information from secondary and tertiary roadways, weather conditions, roadway incidents and events, construction, and historical traffic patterns.

NAVTEQ – NAVTEQ is a global provider of maps, traffic and location data. NAVTEQ digital location content is used in automotive navigation systems, portable and wireless devices, Internet-based mapping applications, and government and business solutions. NAVTEQ delivers real-time, personalized traffic data on a map. The data includes traffic flow conditions with speed values, unplanned incidents (accidents and stalled vehicles), and planned incidents (road construction and closures).



Feasibility

In their current state, these third party data sources are not viable sources for data collection and reporting in the Shasta County region. This is primarily since most of these services rely on subscribed users serving as probe points. This may be a limiting factor in Shasta County.

Tools for real-time traffic reporting rely on the infrastructure that can gather the necessary data. For these tools to be effective, traffic data needs to be collected on a more frequent basis, likely every 30 seconds from regularly-spaced detection stations. Once the data is collected, it will need to be placed into a database where the system can access and reference the data. This system has the ability to provide travel times and real-time congestion information.

Though not needed by the District until a time when recurring congestion is expected, this type of system can be implemented to have functions similar to traveler information websites like 511 or Google Maps. These systems utilize real-time data to provide information such as congestion, predicted travel times, and incident alerts. If the District implements a real-time system like these, performance monitoring would be necessary. The effort of performance monitoring can be high, but it is vital to ensure that the system is providing accurate, reliable, and beneficial information. Costs that will incur from an implementation of these tools would be from a combination of both the technology upgrades to gather the data as well as the software and system upgrades to support a robust forecasting and monitoring tool.



V. IMPLEMENTATION PLAN

A. Alternatives Analysis

Through an evaluation of the District's needs and gaps in ITS infrastructure, alternatives to address each gap using potential technologies as previously discussed have been provided in the attached Alternatives Analysis table (**Appendix C**). Factors that were considered in the determination of alternatives include the feasibility of each potential technology, priority of each need, influence of existing equipment, and extent of each gap.

For each gap discussed earlier, the Alternatives Analysis table presents a set of alternatives, a priority level based on stakeholder input, the elements required for each alternative (i.e., equipment and new infrastructure), estimated installation costs per location, pros and cons, and what enhancement the alternative provides in terms of data collection procedures. The installation costs for the detection technologies do not include power and communication costs. The costs for alternative power and communications included in the alternatives analysis are the same as those presented in tables 1, 2, and 3 above.

Using this analysis approach, each potential solution can be evaluated side-by-side to determine the preferred alternative. The preferred alternative is not solely based on lowest cost, but also considers ease of integration with existing system, functionality, and maturity of technology. The following table summarizes the preferred alternative to address each gap.



Table 4: Gaps and Preferred Alternatives

Gap	Preferred Alternative
Lack of permanent count stations	Upgrade existing temporary stations to permanent stations
Lack of permanent count stations at desired locations	Install permanent loop detector stations at new locations
Limited communication network	Deploy GPRS in the short-term to bring detector stations online, then covert to an agency owned wireless network to connect to hubs on a fiber communication backbone as the infrastructure is installed.
Lack of origin-destination data	Install Bluetooth demonstration and permanent system at County and SCUR gateways
Lack of origin-destination central processing system	Integrate commercial off-the-shelf system to existing Caltrans system
Central system cannot monitor congestion or incidents	Upgrade existing functionality of TSN/PeMS process
No access to Caltrans data by external agencies	Upgrade PeMS to automatically download census data from TSN. If the project for the PeMS upgrade is not anticipated in the near future, install third-party software data processing and reporting tool.

Based on stakeholder’s feedback, the most important stakeholder priorities are to collect data to assist with the travel demand modeling, and to improve the availability and access of the volume data. The following describes the approach to developing the projects that will accomplish these goals.

B. Implementation Plan

Based on the table in **Appendix C** and the methodology described above, individual implementable projects have been identified to meet the needs of SRTA and Caltrans. The list of projects is presented in **Appendix D** and is based on identification of strategic corridors and feasible technologies. The projects focus on manageable, modular projects that enhance Caltrans’ existing ITS infrastructure while considering the priorities and goals of SRTA and Caltrans. They can be deployed as project funds become available. Each project includes details of the recommended project with estimated planning level costs for project development, capital construction, as well as operations and maintenance costs. The estimated project costs can vary depending on power and communication, however, for the purposes of this document, the costs presented in the Implementation plan assume hardwire power. The projects also assume GPRS/Cellular communications. The discussion below summarizes the categories of the projects proposed in **Appendix D** for the data collection system:



1. EXISTING CONDITIONS

- a. Origin-Destination Stations – The greatest data collection desire for the SRTA and Caltrans D2 planning groups is to provide information to determine the number of inter-, intra-, and thru-regional trips. Origin-Destination detection stations located at the five main urban gateways to the SCUR would provide the majority of the trip information into and out of the region. As described in the introduction, the five gateways are:

Gateway 1: Highway 299 west of French Gulch Road;
Gateway 2: Interstate 5 south of Fawndale Road;
Gateway 3: Highway 299 east of Dry Creek Road;
Gateway 4: Highway 44 east of Deschutes Road; and
Gateway 5: Interstate 5 north of Bowman Road.

The two technologies most feasible for providing origin-destination information are Bluetooth technology and automatic license plate readers. Bluetooth technology is an emerging technology currently being deployed by a number of agencies on a trial basis. Though there are concerns of Bluetooth technology reliability in transportation applications, it is potentially a very cost effective approach to Origin-Destination tracking. As listed in **Appendix D**, a pilot test should be conducted along a major corridor (preferably I-5) to measure the reliability and accuracy of Bluetooth technology specifically within the region. ALPR technology is a more established and reliable method of collecting O-D information and has been previously utilized by Caltrans District 2. However, it is considerably more expensive and should be considered if a Bluetooth solution does not provide acceptable data.

- b. Deploy more permanent count stations - Since Shasta County does not presently experience extensive recurring congestion over a long peak duration, there is no need to maintain an expansive and thorough data collection system that collects and distributes data for congestion monitoring and incident management. However, SRTA and Caltrans Planning have identified the desire to collect volume data on a continuous basis and make it available within three to six months. Ideally, volume would be collected at every interchange and would capture all vehicles entering and exiting the freeway as well as volume data on the mainline. Existing permanent count stations currently collect data on a continuous basis; therefore, installing new permanent stations or converting non-permanent count stations to permanent stations would provide the data needed by the planning groups.

The number of locations for new or upgraded count stations was identified based on an analysis of existing count station locations and the desired coverage area. All existing stations were considered for upgrades, while new stations are recommended for areas where mainline volume between interchanges is currently not captured. There are two types of proposed typical count station configurations:



- **New Count Station Configuration:** Utilize newly installed mainline loops connected to existing on and off-ramp loops, all connected to one control cabinet.
- **Upgraded Count Station Configuration:** Utilizes upgraded mainline loops connected to existing on and off-ramp loops, all connected to one control cabinet.

These typical configurations, shown in **Figure 3** below, would provide data to calculate and monitor the entering, exiting, and through volume along the mainline.

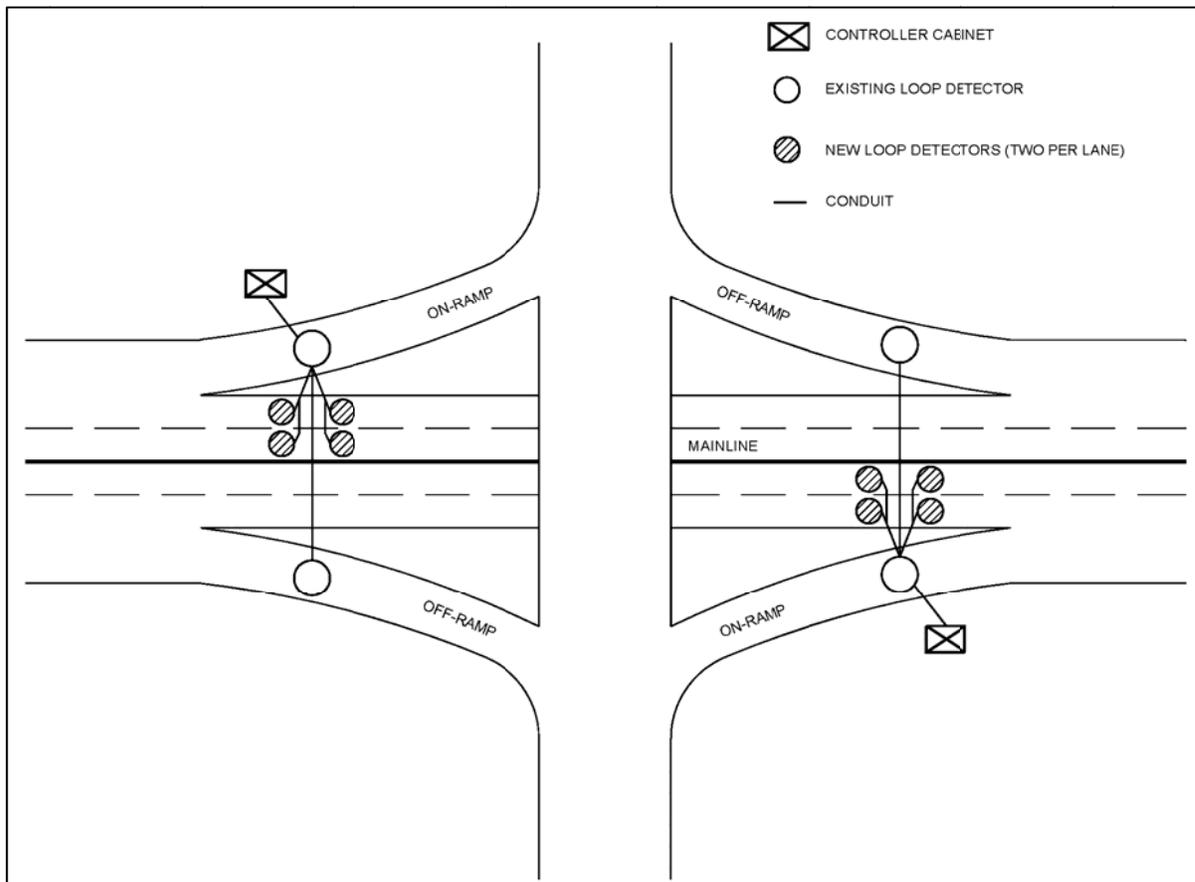


Figure 3: Typical Count Station Configuration

A large benefit of this implementation approach is there would be very little or no integration costs since this method matches existing deployments by District 2. Since Census staff currently must manually deploy Diamond Counters (and tubes at certain locations) at all temporary count stations, having permanent count stations at recommended locations would allow for remote downloading of volume data thereby



reducing the amount of field work currently required. Through this effort savings, the Census group would be available to perform other tasks such as TMC support during adverse weather or additional data analysis.

New and upgraded count stations were divided into project groups based on 2011 AADT volumes at each of the interchanges. Areas that experience higher volumes were given preference in project priority. After taking volumes into consideration, geographic locations of the count stations were considered so that the locations would be logical and complete in terms of corridor management. This would ensure that for the most part, installation of new or upgraded count stations would commence so that only one area of the SCUR would be in construction at one time. Installations of new stations and upgrades of existing count stations can also be done as part of other construction projects and may provide ITS project cost savings.

Converting the non-permanent count stations to permanent stations will position the region for a future ramp metering system and a real-time data collection system when recurring congestion occurs. Since the installation of the permanent count stations will provide the necessary infrastructure of controller cabinet, power, communication, and loops, the only modifications required to implement a TMS station would be to replace the existing Diamond counter with a new 2070 controller and loop detector cards.

Appendix E is a map that shows the locations of the new and upgraded count stations, project group limits and their project numbers. The project numbers correspond directly with the table in Appendix C which lists the project limits, project elements, and project costs.

- c. Implement central system for data exchange – The implementation of a data exchange system can be separated into three different approaches:
 1. In the event that the PeMS system is upgraded by Caltrans Headquarters in the near future, this will allow for automatic downloading of census information from TSN as soon as it is posted. PeMS would provide stakeholders with the vehicle traffic volume data access and reporting tool desired. Under this approach, training workshops would be required to help familiarize SRTA and other agencies with PeMS data processing and reporting capabilities.
 2. If a project to upgrade PeMS is too far out on the horizon, SRTA and Caltrans can partner to deploy a commercial off-the-shelf software solution that will simplify the exporting and reporting process. SRTA and Caltrans can obtain the precise data and format that is most desirable and the system could integrate with existing Caltrans equipment. Depending on the solution selected, it may also be necessary to install a communications link that enables SRTA to directly access and export the data.
 3. The simplest and potentially least expensive option in terms of deployment would be to implement a central software interface that would be able to export and compile raw traffic data in excel format. However, this alternative is not desired by SRTA because it would require more staff resources to manually disseminate data and create reports. This option may be viable in the short-term until one of the two



data exchange options above is implemented. The disadvantage may be that the data is not in a format most preferred by SRTA.

2. FUTURE CONDITIONS

- a. Implement equipment for real-time data collection system – At a point in the future when recurring traffic becomes common over a longer duration of the peak period, the District may desire a data collection system capable of providing real-time speed and congestion information. If the existing permanent count station infrastructure is expanded as described above, Caltrans will only need to install new controllers and detector card equipment to convert the count stations to traffic monitoring stations. Since the infrastructure construction costs of deploying TMS will not be required, the saved funds can then be applied to developing or integrating a central traffic monitoring system.

C. Operations and Maintenance Plan

Caltrans is currently responsible for operating all data collection equipment within Caltrans right-of-way. This includes loop detectors, MVDS, cabling, communications equipment, field cabinets, and central storage and processing equipment. With the deployment of additional equipment, it is likely that Caltrans will continue to operate the new equipment. If additional software is deployed to provide SRTA with customized reporting of origin-destination or real-time data, SRTA may share responsibility for operating and maintaining the software and the communication connection to Caltrans data.

Maintenance activities fall into two categories: preventive and corrective. Preventive maintenance involves the periodic calibrating, cleaning, or fine tuning of equipment to prolong the acceptable performance of the equipment. Corrective maintenance involves the troubleshooting, repair, or replacement of failed equipment, usually prioritized based on severity of the failure.

Scheduling preventive maintenance measures and timing should be based on manufacturers' recommendations. Using these manufacturer recommendations, Caltrans should develop a maintenance checklist for maintenance crews to use and develop a schedule for when the periodic check-ups should take place. Depending on whether in-house expertise exists, maintenance may be out-sourced to provide faster and cost-effective response to maintenance needs. Additionally, subject to manufacturers' warranties, device operations may need to be recertified by the manufacturer for proper operation (e.g., video detection adjustment/calibration). Recertifying the devices usually involves field testing and reconfiguring the devices to ensure proper device operations. Manufacturer recertification should be negotiated at the time of purchase.

To address corrective maintenance, Caltrans must develop contingency plans to address the inevitable unknown device failures. Devices may inadvertently be damaged or may unexpectedly fail due to unforeseen device malfunctions. To address these issues, Caltrans should budget for an inventory of spare equipment for future replacement of failed equipment. It is an industry standard to maintain two to three percent of the total deployment for adequate spare devices to have on hand for maintenance purposes, plus an open Purchase Order for seven to eight percent (totaling 10 percent total).



In addition to maintenance activities, there are also replacement costs due to upgrading legacy equipment or end of lifespan that Caltrans should consider. To prepare and anticipate the need to upgrade in the future, Caltrans should plan for replacing existing equipment based on estimated end of useful lifespan considerations.

In the event that detection equipment is deployed where Caltrans and SRTA have agreed to shared, there could be an Operations and Maintenance Memorandum of Understanding executed between Caltrans and SRTA, if needed, that captures the responsibilities of each agency, including the following:

- Power and communications costs
- Initial capital costs
- Equipment replacement/maintenance responsibilities and costs
- Privileges for utilizing data
- Responsibilities for maintaining useful data
- Opportunities and limitations for system expansion
- Data sharing opportunities and limitations
- Cost sharing

D. Funding

While some of the following funding sources may not be data collection specific, data collection elements can be incorporated into capital improvement projects falling under these funding source requirements.

- **Congestion Mitigation and Air Quality Program (CMAQ)** – This program was established by the 1991 Federal Intermodal Surface Transportation Efficiency Act (ISTEA) and was re-authorized with the passage of SAFETEA-LU in 2004. CMAQ funds are directed to transportation projects and programs that contribute to the attainment or maintenance of National Ambient Air Quality Standards in nonattainment or air quality maintenance areas for ozone, carbon monoxide, or particulate matter under provisions in the Federal Clean Air Act. Eligible projects are as follows: public transit improvements; high occupancy vehicle (HOV) lanes; Intelligent Transportation Infrastructure (ITI); traffic management and traveler information systems (e.g., electric toll collection systems); employer-based transportation management plans and incentives; traffic flow improvement programs (signal coordination); fringe parking facilities serving multiple occupancy vehicles; shared ride services; bicycle and pedestrian facilities; flexible work-hour programs; outreach activities establishing Transportation Management Associations; fare/fee subsidy programs; engine diesel retrofits; alternative fuel vehicles; vehicle congestion pricing; freight intermodal projects; idle reduction projects; and under certain conditions, PM-10 projects. Routine rehabilitation projects and projects that are capacity increasing or highway expansion typically are not eligible. Operations projects may be funded for only three years.

Shasta County's air quality currently meets the Federal Clean Air Act requirements and therefore is not eligible for these funds at this time. However, if air quality were to degrade enough to make Shasta County available for these funds, vehicle detection projects may possibly qualify under this program.



- **Shasta County Air Quality Management District (SCAQMD)** - “Endeavors to manage and enhance the air quality resources of Shasta County through a balanced program of environmental oversight and protection of public health.” Typical grant recipient projects include replacing outdated diesel vehicles and equipment and wood stove rebates. While this is not a direct funding source for SRTA at this present time, potential opportunities may be available in the future to accomplish greenhouse reduction measures presented in the Shasta Regional Climate Action Plan.
- **Development Impact Fees** - Traffic impact mitigation fees assessed to new development in the local cities and/or the County could be used to fund a portion of the deployment of new detection. Per California law, impact fees can only be assessed to a list of projects or improvements determined to meet nexus requirements from impacts of development. Specific data collection solutions may not be explicitly called out for in an approved project list, but could be part of roadway construction.
- **State Funding Opportunities** – At the State level, Intelligent Transportation System (ITS) funding (including vehicle detection systems) is provided as part of the statewide transportation programming and funding process administered by Caltrans in coordination with the Metropolitan Planning Organizations (MPOs) and the Regional Transportation Planning Agencies (RTPAs).
- **State Highway Operation and Protection Plan (SHOPP)** – SHOPP is a program that provides funding for highway and bridge improvement projects related to rehabilitation, operations, and safety.
- **State Transportation Improvement Program (STIP)** - The State Transportation Improvement Program (STIP) is a multi-year capital improvement program resource management document to assist the State and local entities to plan and implement transportation improvements, and to utilize resources in a cost-effective manner. All STIP projects must be capital projects (including project development costs) needed to improve transportation. These projects generally may include, but are not limited to, improving State highways, local roads, public transit (including buses), intercity rail, pedestrian and bicycle facilities, grade separations, transportation system management, transportation demand management, sound walls, intermodal facilities, safety, and environmental enhancement and mitigation projects. STIP funding is split 25 percent to Interregional Transportation Improvement Program (ITIP) projects nominated by Caltrans, and 75 percent to Regional Transportation Improvement Program (RTIP) projects decided by regional agencies. Projects are presented as part of a complete ITIP or RTIP to the California Transportation Commission (CTC) for approval and inclusion in the STIP. The CTC, upon review of the ITIP or RTIP, can accept or reject the program in its entirety.
- **Caltrans Planning Grant Program** - A call for projects was recently issued for 2013/14 for this program offering funding opportunities in Environmental Justice (EJ), Community Based Transportation Planning (CBTP), Partnership Planning, and Transit Planning. The typical grant for



each of these categories has a cap of \$300,000 (\$250,000 for EJ). Future years may offer similar opportunities that could be applicable to some of the County's trial and/or strategic planning programs.

- **SB 375/AB 32** - SB 375 is California state legislation that requires the development of regional reduction targets for greenhouse gas emissions in long-range regional planning for land-use, housing, and transportation. The legislation requires SRTA to direct the development of a Sustainable Communities Strategy (SCS) for the region. If the state-determined targets cannot be identified and met through the SCS, an Alternative Planning Strategy (APS) can be developed and employed in its place. SB 375 aims to reduce Vehicle Miles Traveled (VMT) and encourage live/work and sustainable development for the future.

California's major initiatives for reducing climate change or greenhouse gas (GHG) emissions are outlined in Assembly Bill 32 (signed into law 2006), 2005 Executive Order, and a 2004 ARB regulation to reduce passenger car GHG emissions. These efforts aim at reducing GHG emissions to 1990 levels by 2020 - a reduction of approximately 30 percent, and then an 80 percent reduction below 1990 levels by 2050.

Both pieces of legislation (SB 375 and AB 32) require the adoption of targets and the development of plans to achieve those targets within the required time frame. They do not provide for additional funding for such activities, but rather re-direct current funding towards greenhouse reducing approaches.

AB 32 may present opportunities for an innovative funding approach taking advantage of carbon emission credits through the use of the cap and trade mechanism for emissions management. This approach would involve a Carbon Study by the County that defines the carbon emissions savings that are a direct result of the vehicle detection enhancements defined in this document. If these savings can be proven to be sustainable, they can be eligible for verification and certification by an independent verification organization and traded as carbon offsets. At the time of this report, two bills, AB 1532 and SB 1572 have been introduced. These bills "would create the Greenhouse Gas Reduction Account within the Air Pollution Control Fund. The bill would require monies, as specified, collected pursuant to a market-based compliance mechanism be deposited in this account. The bill also would require those monies, upon appropriation by the Legislature, be used for purposes of carrying out the California Global Warming Solutions Action of 2006." In short, data collection technologies that will help monitor and reduce congestion and emissions have the potential of receiving funding from this account.



VI. SUMMARY

The SRTA and Caltrans District 2 have partnered to develop a plan for an integrated traffic data collection system that will collect and distribute timely, reliable, accurate, and quality traffic data. The overall project goal is to develop a plan to deploy an enhanced data collection system that provides agencies with current and frequent traffic data for planning, developing and managing an effective transportation system. This system will build upon the current data collection infrastructure utilized by Caltrans District 2 for their Census program.

Based on several stakeholder workshops, the ultimate recommended system is one that will expand the existing system through the use of already deployed technology requiring little integration effort and no changes to existing data collection procedures. The following is a summary of project recommendations to deploy an Integrated Traffic Data Collection System:

1. Expand the network of permanent detector count stations through the installation of new detection stations or upgrade of temporary detection stations at every interchange throughout the SCUR. At each interchange, the count stations will monitor mainline, on-ramp, and off-ramp traffic providing engineers and planners with volume, speed, and classification data.
2. Provide permanent communications and detection equipment to automatically collect data on a more frequent basis. Currently, data is collected based on a schedule set for Census data. Traffic data at some locations are only collected once every three years via manual data collection processes. A permanent data collection system will provide current, timely data to better evaluate traffic trends, develop performance measures, and validate traffic models. An additional benefit of expanding the permanent count station network is that over time the additional infrastructure (controller cabinets, conduits, power, communication, etc.) will prepare the region for future traffic congestion monitoring and ramp metering. When the time comes that Caltrans District 2 and SRTA wish to deploy technology for real-time congestion monitoring, the expensive infrastructure will be in place and minimal device upgrades will be required. Additionally, this recommended system will provide the District with a single data collection network capable of census data collection and traffic monitoring.
3. Conduct a Bluetooth Pilot Test to evaluate the performance and data samples for origin-destination data. If results are acceptable, deploy Bluetooth field equipment at Gateway locations. This will enable SRTA to collect and analyze origin-destination data for intra- and inter-regional trips.
4. If the Caltrans Headquarters' project to automate the interface between TSN and PeMS is not scheduled for the near future, SRTA should consider deploying third party software with data processing and reporting capabilities. The tool should be able to seamlessly compile count data provided by Caltrans and integrate with various types of detection technologies to allow for additional future expansion. This will provide the SRTA a simpler and quicker process for accessing and manipulating traffic count data.



Table 5 below summarizes the planning level costs associated with the recommended Traffic Data Collection System project that will create a system that fits the data needs of SRTA and Caltrans District 2.

Table 5: Summary of Proposed Project Costs

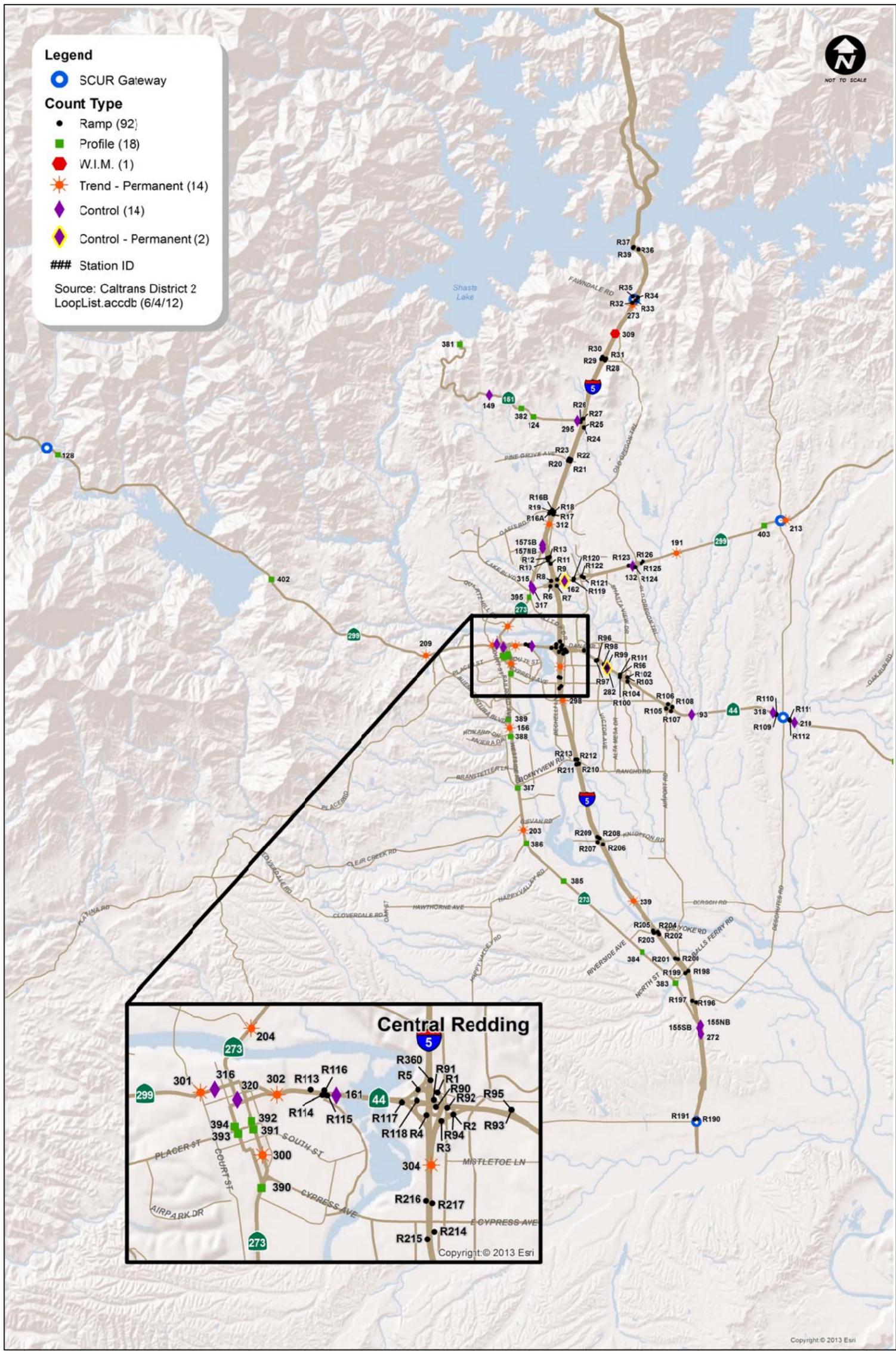
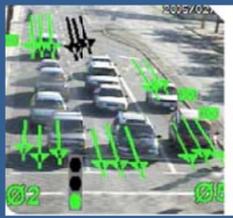
Project	Installation Costs	O&M Costs (Annually)
Gateway Origin-Destination Stations	\$510,000	\$58,000
Detector Project 1	\$851,000	\$39,000
Detector Project 2	\$496,000	\$22,000
Detector Project 3	\$562,000	\$25,000
Detector Project 4	\$562,000	\$25,000
Detector Project 5	\$284,000	\$13,000
Detector Project 6	\$142,000	\$6,000
Detector Project 7	\$199,000	\$9,000
Total Installation Costs:	\$3,606,000	-
Total Annual O&M Costs:	-	\$197,000
Future Conditions		
Convert stations from Detector Project 1 to TMS	\$79,000	\$15,000
Convert stations from Detector Project 2 to TMS	\$46,000	\$9,000
Convert stations from Detector Project 3 to TMS	\$53,000	\$11,000
Convert stations from Detector Project 4 to TMS	\$53,000	\$11,000
Convert stations from Detector Project 5 to TMS	\$26,000	\$5,000
Convert stations from Detector Project 6 to TMS	\$13,000	\$9,000
Convert stations from Detector Project 7 to TMS	\$20,000	\$4,000
Total Installation Costs:	\$290,000	-
Net Increase Annual O&M Costs¹:	-	\$64,000

¹ Net increase in O&M costs reflects the additional costs of Traffic Monitoring Stations due to additional communication and power requirements.

SRTA and Caltrans District 2 should pursue multiple funding sources for the deployment of the recommended integrated data collection system. Both Federal and State funding sources should be monitored and pursued when grant opportunities are released. California's new Cap & Trade program may provide an innovative funding source to fund capital projects that meet ITS needs and help reduce vehicle emissions. The stakeholders also should evaluate the prospects for including data collection system elements into other capital projects, similar to the inclusion of fiber installation in the I-5 expansion project currently taking place.

Appendix A

Existing Count Station Locations



EXISTING COUNT STATION LOCATIONS

Appendix B
Detector Technology Evaluation
Matrix



APPENDIX B - DETECTOR TECHNOLOGY EVALUATION MATRIX



Technology	Data Collected						Accuracy	Lane Closure for Installation	Mounting Configuration	Calibration Difficulty	Maintenance Frequency	Verification Frequency	Integration Difficulty	Power Supply (Hardwire or Solar)	Estimated Lifespan	Expected Long-Term Viability	Estimated Annual O&M Staff Hours (per location)
	Volume	Speed	Occupancy	Classification	Travel Time	Origin-Destination											
Inductive Loop	x	x	x	x			Excellent	Yes	Roadway Surface (2 loops per lane)	Low	Low	Low	Low	Hardwire or Solar	15 to 20 Years	Excellent	28 hours
Radar	x	x	x	x			Very Good	Side Fire - No Overhead - Yes	Overhead or Side Fire (1 per cross section)	Low to Moderate	Moderate	Moderate	Low to Moderate	Hardwire or Solar	10 to 15 Years	Very Good	40 Hours
Video Image Detection	x	x	x	x			Good	Side Fire - No Overhead - Yes	Overhead or Side Fire (1 per cross section)	Moderate	Moderate	Moderate	Low to Moderate	Hardwire	7 to 10 Years	Excellent	48 Hours
License Plate Reader					x	x	Very Good	Side Fire - No Overhead - Yes	Overhead or Side Fire (1 per cross section)	Low	Moderate	Moderate	Moderate to High	Hardwire or Solar	10 Years	Good	48 Hours
Magnetometer	x	x	x				Very Good	Yes	Sensors in roadway surface (1 per lane); Access Point and Repeaters pole mounted	Moderate	Moderate	Low	Low	Hardwire or Solar for Access Point; Battery for Sensors and Repeaters	5-10 Years	Very Good	36 hours
Acoustic	x	x	x				Good	Side Fire - No Overhead - Yes	Overhead or Side Fire (1 per cross section)	Moderate	High	High	Moderate	Hardwire or Solar	8 Years	Fair	50 Hours
Bluetooth	x	x	x		x	x	Good	No	Side Fire (1 per cross section)	Low	Moderate	Moderate	Moderate to High	Hardwire or Solar	Unknown	Fair to Good	40 Hours
Toll Tag (RFID)					x	x	Good	Side Fire - No Overhead - Yes	Roadway Surface	Moderate	Low	Moderate	Moderate to High	Hardwire or Solar	8 to 10 Years	Good	40 Hours
Third-Party GPS-Based Traffic Data		x			x	x	Very Good	None	None	Moderate	Moderate	Moderate	High	Not Applicable	Unknown	Very Good	Unknown

Appendix C

Alternatives Analysis



APPENDIX C - ALTERNATIVE ANALYSIS



Gap	Alternatives	Priority	Optional Solutions	Pros	Cons	Elements Required (per location)	Estimated Unit Costs	Estimated Installation Costs (per location, excluding power and communications)	Estimated Annual O&M Staff Hours (per location)
#1: Lack of permanent count stations.	Upgrade non-permanent stations to permanent stations.	High	Detector Loops (Assumes loops are already existing)	<ul style="list-style-type: none"> Little or no integration costs Standard technology used state-wide Excellent accuracy and long-term viability Consistent with current deployment of permanent stations 	<ul style="list-style-type: none"> Traffic impact during construction Reinstallation or repair of loops degrades pavement life 	<ul style="list-style-type: none"> 334 Controller Cabinet/Foundation Diamond Counter 250' of Conduit (including DLCs) 	<ul style="list-style-type: none"> \$15,000 \$4,000 \$16,250 	\$35,250	28
			Radar Detection	<ul style="list-style-type: none"> Low integration effort Very good accuracy and long-term viability Can function as a stand-alone system via wireless connection to TMC Little to no construction impact 	<ul style="list-style-type: none"> Moderate to high calibration difficulty High truck volume can decrease accuracy due to occlusion 	<ul style="list-style-type: none"> Radar Detector and Controller Pole/Foundation 	<ul style="list-style-type: none"> \$8,000 \$6,000 	\$14,000	40
			Magnetometer	<ul style="list-style-type: none"> Low integration effort Low communication bandwidth required Very good accuracy and long-term viability Quick installation minimizes traffic impact 	<ul style="list-style-type: none"> Cannot detect stopped vehicles Smaller detection zone per unit Traffic impact during construction Can experience calibration issues 	<ul style="list-style-type: none"> 3 Magnetometers and Controller Access Point Pole/Foundation 	<ul style="list-style-type: none"> \$12,000 \$3,500 \$6,000 	\$21,500	36
	Upgrade non-permanent stations to TMS.	Medium	Detector Loops (Assumes loops are already existing)	<ul style="list-style-type: none"> Can provide automatic and frequent data collection to a central system with automatic polling every 30 seconds. Little or no integration costs Standard technology used state-wide Excellent accuracy and long-term viability 	<ul style="list-style-type: none"> Needs ATMS or central system to collect and store data Traffic impact during construction Reinstallation or repair of loops degrades pavement life 	<ul style="list-style-type: none"> 334 Controller Cabinet/Foundation 170/2070 Controller 3 Detector Cards 250' of Conduit (including DLCs) 	<ul style="list-style-type: none"> \$15,000 \$4,000 \$750 \$16,250 	\$36,000	28
#2: Lack of permanent count stations installed at locations where data is most desired.	Install new permanent count stations at regular intervals on the mainline between major interchanges and at on and off ramps.	High	Detector Loops	<ul style="list-style-type: none"> Little or no integration costs Standard technology used state-wide Excellent accuracy and long-term viability 	<ul style="list-style-type: none"> Traffic impact during construction Moderate to high maintenance required 	<ul style="list-style-type: none"> 6 Detector Loops 334 Controller Cabinet/Foundation Diamond Counter 250' of Conduit (including DLCs) 	<ul style="list-style-type: none"> \$3,900 \$15,000 \$4,000 \$16,250 	\$39,150	28
			Radar Detection	<ul style="list-style-type: none"> Low integration effort Very good accuracy and long-term viability Can function as a stand-alone system via wireless connection to TMC 	<ul style="list-style-type: none"> Moderate to high calibration difficulty High truck volume can decrease accuracy due to occlusion 	<ul style="list-style-type: none"> Radar Detector and Controller Pole/Foundation 	<ul style="list-style-type: none"> \$8,000 \$6,000 	\$14,000	40
			Magnetometer	<ul style="list-style-type: none"> Low integration effort Low communication bandwidth required Very good accuracy and long-term viability 	<ul style="list-style-type: none"> Cannot detect stopped vehicles Smaller detection zones per unit Traffic impact during construction 	<ul style="list-style-type: none"> 3 Magnetometers and Controller Access Point Pole/Foundation 	<ul style="list-style-type: none"> \$12,000 \$3,500 \$6,000 	\$21,500	36
	Install new traffic monitoring system (TMS) stations at regular intervals on the mainline between major interchanges and at on and off ramps.	Medium	Detector Loops	<ul style="list-style-type: none"> Can provide automatic and frequent data collection to a central system with automatic polling every 30 seconds. Little or no integration costs Standard technology used state-wide Excellent accuracy and long-term viability 	<ul style="list-style-type: none"> Needs ATMS or central system to collect and store data Traffic impact during construction Reinstallation or repair of loops degrades pavement life 	<ul style="list-style-type: none"> 6 Detector Loops 334 Controller Cabinet/Foundation 170/2070 Controller 3 Detector Cards 250' of Conduit (including DLCs) 	<ul style="list-style-type: none"> \$3,900 \$15,000 \$4,000 \$750 \$16,250 	\$39,900	28
#3: Limited communication network to allow for regular polling of data.	Convert communication lines to wireless network communication.	High	Wireless to T1	<ul style="list-style-type: none"> Preferred if cabling/conduit do not exist Minimal disturbance to traffic or environment during installation 	<ul style="list-style-type: none"> Must have line of sight 	<ul style="list-style-type: none"> Wireless Connection Ongoing Monthly Service 	<ul style="list-style-type: none"> \$2,000 \$300/mo 	\$2,000 + \$300/month	-
			ISDN	<ul style="list-style-type: none"> Minimal disturbance to traffic or environment during installation 	<ul style="list-style-type: none"> Must have an access point in vicinity of equipment Requires come conduit installation to demarcation point Not preferred by Caltrans 	<ul style="list-style-type: none"> ISDN Modem Ongoing Monthly Service 	<ul style="list-style-type: none"> \$2,000 \$150/mo 	\$2,000 + \$150/month	-
			Cellular	<ul style="list-style-type: none"> Minimal disturbance to traffic or environment during installation 	<ul style="list-style-type: none"> Requires dial-up process to access data Limited bandwidth capability 	<ul style="list-style-type: none"> Telephone or private cellular modem Ongoing Monthly Service 	<ul style="list-style-type: none"> \$2500 \$50/mo 	\$2500 + \$50/month	-
	Convert communication lines to hardwire network communication.	Medium	Fiber Optic	<ul style="list-style-type: none"> Robust, reliable communication medium Higher bandwidth capabilities 	<ul style="list-style-type: none"> Costly solution if new conduit is required 	<ul style="list-style-type: none"> Agency-Owned Fiber Optic Cable Ethernet Switch 	<ul style="list-style-type: none"> \$750,000/mile 	\$750,000/mile	-
			Copper Twisted Pair	<ul style="list-style-type: none"> Robust, reliable communication medium 	<ul style="list-style-type: none"> Costly solution if new conduit is required 	<ul style="list-style-type: none"> Agency-Owned Copper (Twisted-Pair) Cable Modem 	<ul style="list-style-type: none"> \$700,000/mile 	\$700,000/mile	-



APPENDIX C - ALTERNATIVE ANALYSIS



Gap	Alternatives	Priority	Optional Solutions	Pros	Cons	Elements Required (per location)	Estimated Unit Costs	Estimated Installation Costs (per location, excluding power and communications)	Estimated Annual O&M Staff Hours (per location)
#4: Lack of O&D data collection equipment.	Install count stations at County gateways.	High	License Plate Reader	<ul style="list-style-type: none"> Minimal traffic impact during construction Can be a stand-alone system Minimal traffic impact during installation 	<ul style="list-style-type: none"> Uses proprietary software to digitize and translate images Requires effort to integrate with existing process and procedures 	<ul style="list-style-type: none"> Automatic License Plate Readers (ALPR) ALPR Software and User License Pole and Foundation 	\$50,000 \$6,600 \$6,000	\$62,600	48
			Bluetooth	<ul style="list-style-type: none"> Low costs Very good accuracy Minimal traffic impact during construction Can be a stand-alone system 	<ul style="list-style-type: none"> High integration effort Insufficient sample size concerns Long-term viability is questionable due to increasing cellular device security restrictions 	<ul style="list-style-type: none"> Bluetooth Detector and Controller Pole/Foundation 	\$2,500 \$6,000	\$8,500	40
	Install count stations at SCUR gateways.	High	License Plate Reader	<ul style="list-style-type: none"> Minimal traffic impact during construction Can be a stand-alone system when paired with wireless communication to TMC. 	<ul style="list-style-type: none"> Uses proprietary software to digitize and translate images Requires effort to integrate with existing process and procedures 	<ul style="list-style-type: none"> Automatic License Plate Readers (ALPR) ALPR Software and User License Pole and Foundation 	\$50,000 \$6,600 \$6,000	\$62,600	48
			Bluetooth	<ul style="list-style-type: none"> Low costs Very good accuracy Minimal traffic impact during construction 	<ul style="list-style-type: none"> High integration effort Insufficient sample size concerns Long-term viability is questionable due to increasing cellular device security restrictions 	<ul style="list-style-type: none"> Bluetooth Detector and Controller Pole/Foundation 	\$2,500 \$6,000	\$8,500	40
#5: Lack of O&D central system.	Install separate system at a central facility that communicates solely to O&D count stations.	High	-	<ul style="list-style-type: none"> Will allow the O&D tracking system to operate independently from other data collection system Potential for more off-the-shelf solutions rather than custom development 	<ul style="list-style-type: none"> Increased costs and effort to implement and maintain a secondary central system 	<ul style="list-style-type: none"> Central software Workstation with storage Modem 	-	Varies based on number of installations	Varies based on number of installations
	Integrate detection to a single data collection system	High	-	<ul style="list-style-type: none"> Entire system for O&D data and real-time data is integrated into a single system 	<ul style="list-style-type: none"> Streamlined maintenance and management on a single system 	<ul style="list-style-type: none"> Modify existing process or modify future system to process O&D and other detection data 	-	Varies based on added features	Varies based on added features
#6: Current central system cannot archive or monitor real-time congestion levels or incidents.	Upgrade existing software functionality to create automated polling of non-TSN/PeMS files that are separate from the polls for TSN/PeMS.	Low	-	<ul style="list-style-type: none"> Maintains a single software system for ease of maintenance 	<ul style="list-style-type: none"> Increased costs and effort due to required integration of communications and data processing functionality 	<ul style="list-style-type: none"> Upgrade software functionality Provide archived storage 	-	Varies based on added features	Varies based on added features
	Provide new software used for data processing and real-time monitoring	Low	-	<ul style="list-style-type: none"> Clean interface with detection locations that provide monitoring capabilities Potential for proven off-the-shelf solutions rather than custom development 	<ul style="list-style-type: none"> Increased costs and effort to implement and maintain a secondary central system Effort needed to integrate new software to existing systems 	<ul style="list-style-type: none"> New software that stores and archives data, processes and compiles reports when prompted through a user-friendly interface (e.g., Wavetronix DataCollector, IBM ITS Traffic Management System, MS2's Transportation Data Management System) Workstation with storage 	-	Varies based on software	Varies based on software
	Speed up the time it takes for data to transfer to PeMS from TSN.	High	-	<ul style="list-style-type: none"> Potential for census data to be available as soon as it is posted to TSN No customized software would be required to access data. 	<ul style="list-style-type: none"> SRTA and District 2 have no control over software development schedule. Would still be dependent on existing census data collection schedule. 	<ul style="list-style-type: none"> Caltrans Headquarters PeMS department needs to develop software to automatically download census data from TSN. 	-	None	None



APPENDIX C - ALTERNATIVE ANALYSIS



Gap	Alternatives	Priority	Optional Solutions	Pros	Cons	Elements Required (per location)	Estimated Unit Costs	Estimated Installation Costs (per location, excluding power and communications)	Estimated Annual O&M Staff Hours (per location)
#7: No direct way for external agencies to query or compile reports until data is posted to PeMS.	Create a database and subsequent tool/application that allows a user to query and/or obtain data, prior to the data being posted to TSN or PeMS	Medium	-	<ul style="list-style-type: none"> Potential for proven off-the-shelf solutions rather than custom development Little effort needed to program a user-friendly interface for report querying 	<ul style="list-style-type: none"> Costs incurred from subscribing to third-party services Effort needed to integrate the software. Data integrity compromised 	<ul style="list-style-type: none"> New software that stores and archives data, processes and compiles reports when prompted through a user-friendly interface (e.g., Wavetronix DataCollector, IBM ITS Traffic Management System, MS2's Transportation Data Management System) Workstation with storage 	-	Varies based on software	Varies based on software
			-	<ul style="list-style-type: none"> Removes costs incurred through the use of third-party software Can be customized to the needs and preferences of the District 	<ul style="list-style-type: none"> Extensive effort required to create the database May not be as efficient as software that's already been developed and implemented by others Data integrity compromised 	<ul style="list-style-type: none"> Macro-scripting through database programs such as Excel, Access, MySQL, etc. Interface that a user can request data and reports from. 	-	Varies based on programming efforts	Varies based on programming efforts

Appendix D

Recommended Projects



APPENDIX D - RECOMMENDED PROJECTS



Project Description	Project Limit	Project Location Elements							Planning Level Capital Cost (including project development costs)	O&M Cost (Annual Cost)	Project Dependencies
		Upgrade Non-Permanent Station	Permanent Station to TMS	Install Count Station			Power Source				
				Detector Loops	Bluetooth	ALPR	Solar	Hard-Wire			
CURRENT IMPROVEMENTS											
DATA PROCESSING AND REPORTING											
Deploy third party data processing and reporting tool	N/A								-	-	Cost will vary depending on number of field equipment, desired capabilities and functionality.
GATEWAYS											
Deploy Bluetooth Pilot Test at two Gateways	Gateway 2: I-5 South of Fawndale Rd Gateway 5: I-5 North of Bowman Rd				2			√	\$ 20,000	\$ 6,000	
Install O-D Stations at I-5 Gateways	Gateway 2: I-5 South of Fawndale Rd Gateway 5: I-5 North of Bowman Rd							√	\$ 196,000	\$ 21,000	
Install O-D Stations at CA-299 and CA-44 Gateways	Gateway 1: CA 299 West of French Gulch Rd Gateway 3: CA-299 East of Dry Creek Rd Gateway 4: CA-44 East of Deschutes Rd					3		√	\$ 294,000	\$ 31,000	
Staff Training for License Plate Reader System									-	-	Combine with Project No. 1
Install central system for ALPR integration. Cost included in Capital Cost of Project No. 1									-	-	Combine with Project No. 1
Total Gateway Project Costs									\$ 510,000	\$ 58,000	
DETECTOR PROJECT 1											
Install new permanent mainline station and new permanent on and off-ramp station along I-5	CA-44 to Knighton Road				8			√	\$ 567,000	\$ 26,000	
Install new permanent mainline station and new permanent on and off-ramp station along CA-44	CA-44/Interstate 5 Interchange				4			√	\$ 284,000	\$ 13,000	
Total Project 1 Costs									\$ 851,000	\$ 39,000	



APPENDIX D - RECOMMENDED PROJECTS



Project Description	Project Limit	Project Location Elements							Planning Level Capital Cost (including project development costs)	O&M Cost (Annual Cost)	Project Dependencies
		Upgrade Non-Permanent Station	Permanent Station to TMS	Install Count Station			Power Source				
				Detector Loops	Bluetooth	ALPR	Solar	Hard-Wire			
DETECTOR PROJECT 2											
Install new permanent mainline station and new permanent on and off-ramp station along I-5	Ox Yoke Road to Gas Point Road (South Gateway)			7				√	\$ 496,000	\$ 22,000	
Total Project 2 Costs								\$ 496,000	\$ 22,000		
DETECTOR PROJECT 3											
Install new permanent mainline station and new permanent on and off-ramp station along I-5	Oasis Road to CA-299			6				√	\$ 425,000	\$ 19,000	
Install new permanent mainline station and new permanent on and off-ramp station along CA-299	CA-299/Interstate 5 Interchange			1				√	\$ 71,000	\$ 3,000	
Upgrade existing mainline station to a permanent station and install new permanent on and off-ramp station along CA-299	CA-299/Interstate 5 Interchange	1						√	\$ 66,000	\$ 3,000	Assume loops are existing
Total Project 3 Costs								\$ 562,000	\$ 25,000		
DETECTOR PROJECT 4											
Install new permanent mainline station and new permanent on and off-ramp station along I-5	Fawndale Road (North Gateway) to Pine Grove Avenue			7				√	\$ 496,000	\$ 22,000	
Upgrade existing mainline station to a permanent station and install new permanent on and off-ramp station along I-5	Fawndale Road (North Gateway) to Pine Grove Avenue	1						√	\$ 66,000	\$ 3,000	Assume loops are existing
Total Project 4 Costs								\$ 562,000	\$ 25,000		



APPENDIX D - RECOMMENDED PROJECTS



Project Description	Project Limit	Project Location Elements							Planning Level Capital Cost (including project development costs)	O&M Cost (Annual Cost)	Project Dependencies
		Upgrade Non-Permanent Station	Permanent Station to TMS	Install Count Station			Power Source				
				Detector Loops	Bluetooth	ALPR	Solar	Hard-Wire			
DETECTOR PROJECT 5											
Install new permanent mainline station and new permanent on and off-ramp station along CA-44	Shasta View Drive to Airport Drive			4				√	\$ 284,000	\$ 13,000	
Total Project 5 Costs								\$ 284,000	\$ 13,000		
DETECTOR PROJECT 6											
Install new permanent mainline station and new permanent on and off-ramp station along CA-299	Churn Creek Road to Old Oregon Trail			2				√	\$ 142,000	\$ 6,000	
Total Project 6 Costs								\$ 142,000	\$ 6,000		
DETECTOR PROJECT 7											
Upgrade existing profile station to a permanent profile station	CA-299 at Deschutes Road	1						√	\$ 66,000	\$ 3,000	Assume loops are existing
Upgrade existing mainline station to a permanent station and install new permanent on and off-ramp station along CA-44	CA-44 at Deschutes Road	2						√	\$ 133,000	\$ 6,000	Assume loops are existing
Total Project 7 Costs								\$ 199,000	\$ 9,000		
Total "Current Improvements" Cost¹								\$ 3,606,000	\$ 197,000		



APPENDIX D - RECOMMENDED PROJECTS



Project Description	Project Limit	Project Location Elements							Planning Level Capital Cost (including project development costs)	O&M Cost (Annual Cost)	Project Dependencies	
		Upgrade Non-Permanent Station	Permanent Station to TMS	Install Count Station			Power Source					
				Detector Loops	Bluetooth	ALPR	Solar	Hard-Wire				
FUTURE IMPROVEMENTS												
Convert stations from Project 1 to TMS	I-5: CA-44 to Knighton Road CA-44: CA-44/I-5 Interchange		12						√	\$ 79,000	\$ 54,000	Cabinet and loops are existing
Convert stations from Project 2 to TMS	I-5: Ox Yoke Road to Gas Point Road		7						√	\$ 46,000	\$ 31,000	Cabinet and loops are existing
Convert stations from Project 3 to TMS	I-5: Oasis Road to CA-99 CA-299: CA-299/I-5 Interchange		8						√	\$ 53,000	\$ 36,000	Cabinet and loops are existing
Convert stations from Project 4 to TMS	I-5: Fawndale Road to Pine Grove Avenue		8						√	\$ 53,000	\$ 36,000	Cabinet and loops are existing
Convert stations from Project 5 to TMS	CA-44: Shasta View Drive to Airport Drive		4						√	\$ 26,000	\$ 18,000	Cabinet and loops are existing
Convert stations from Project 6 to TMS	CA-299: Churn Creek Road to Old Oregon Trail		2						√	\$ 13,000	\$ 9,000	Cabinet and loops are existing
Convert stations from Project 7 to TMS	CA-299 at Deschutes Road CA-44 at Deschutes Road		3						√	\$ 20,000	\$ 13,000	Cabinet and loops are existing
Total Future Conditions Project Costs¹									\$ 290,000	\$ 197,000		



APPENDIX D - RECOMMENDED PROJECTS

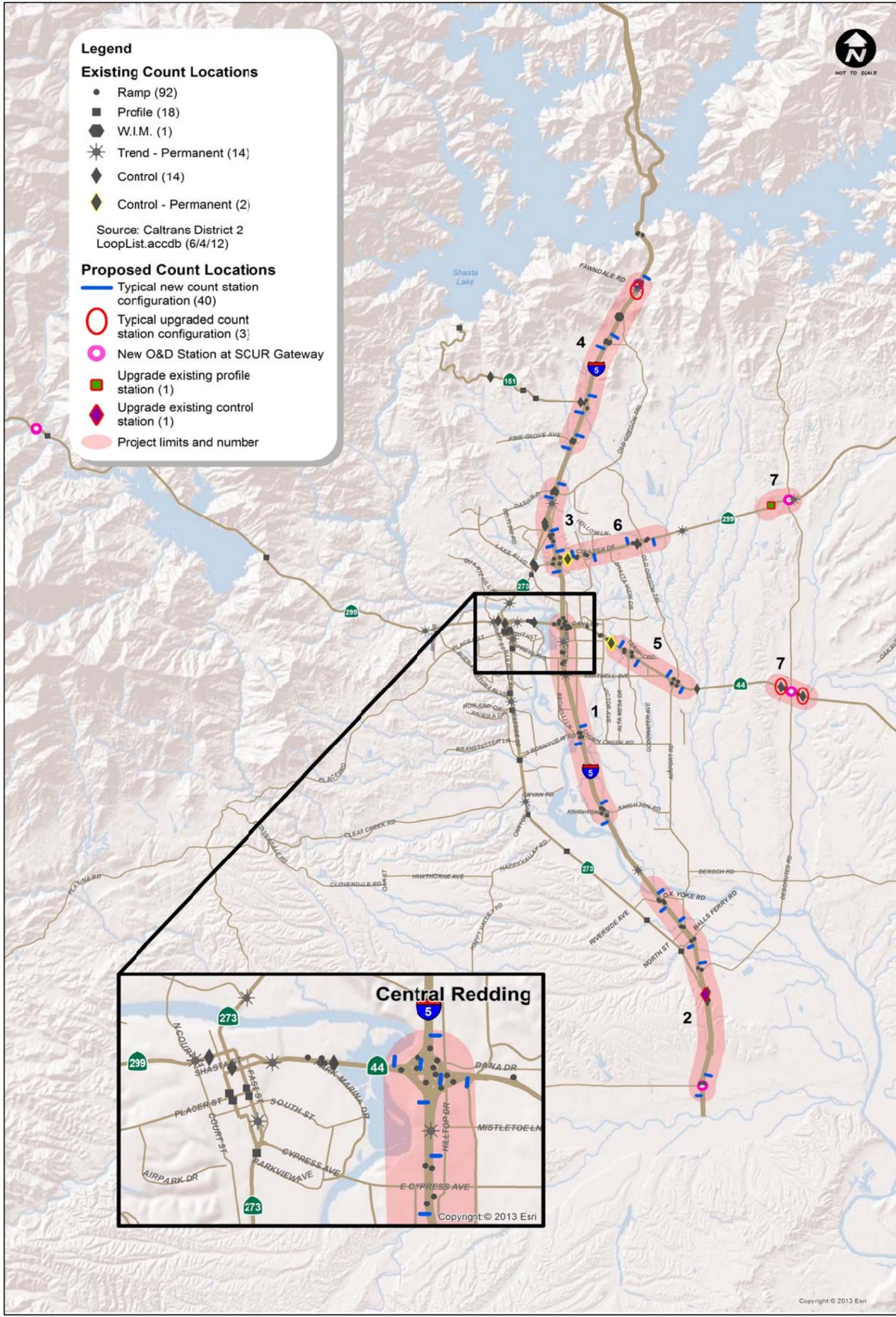
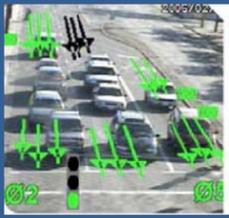


Project Description	Project Limit	Project Location Elements							Planning Level Capital Cost (including project development costs)	O&M Cost (Annual Cost)	Project Dependencies
		Upgrade Non-Permanent Station	Permanent Station to TMS	Install Count Station			Power Source				
				Detector Loops	Bluetooth	ALPR	Solar	Hard-Wire			
COMMUNICATION AND DATA REPORTING ENHANCEMENTS											
Convert communication lines to hardwire network communication in the vicinity of Central Redding.	Oasis Road to Hartnell Avenue								\$ -	\$ -	Cost will vary depending on number of field equipment, desired capabilities and functionality.
Initiation efforts to reduce data processing time from TSN to PeMS on an institutional level.	Caltrans Headquarters								\$ -	\$ -	Cost will vary depending on number of field equipment, desired capabilities and functionality.
Upgrade existing central software functionality to separate polling of non-TSN/PeMS files vs. files intended for TSN/PeMS.	Caltrans Headquarters								\$ -	\$ -	Cost will vary depending on number of field equipment, desired capabilities and functionality.
Install and integrate new software for data processing and real-time monitoring.	SRTA Offices								\$ -	\$ -	Cost will vary depending on number of field equipment, desired capabilities and functionality.
Integrate a new tool/application that allow users to query data prior to the data being posted to TSN or PeMS.	SRTA Offices								\$ -	\$ -	Cost will vary depending on number of field equipment, desired capabilities and functionality.

¹ Cost totals do not include costs related to data processing or data reporting tools. Costs for data processing and reporting may be identified in the future.

Appendix E

Proposed Project Locations



PROPOSED PROJECTS



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