SMART REGION

STARNET GAP ANALYSIS AND FUTURE ROADMAP

FINAL

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**
INTRODUCTION **4**
STARNET Background *4*
Purpose and Goals of STARNET *5*
Approach *7*
STAKEHOLDER FEEDBACK AND CHANGES IN NEEDS **10**
Feedback Summary *10*
GAP ANALYSIS **15**
Summary of Gaps *16*
Analysis of Gaps *18*
NEXT GENERATION STARNET: VISION AND RECOMMENDATIONS **21**
New Vision and Objectives for STARNET *21*
Drivers for New Vision *21*
Recommendations *23*
Program Data Elements *30*
Execution Plan *33*
REFERENCES **33**

APPENDIX A – QUESTIONS FOR MEETINGS
APPENDIX B – FEEDBACK RECEIVED
APPENDIX C – STARNET SYSTEM REQUIREMENT GAPS
APPENDIX D – INDUSTRY REVIEW ADDITIONAL NOTES
APPENDIX E – TYPES OF AGREEMENTS USED IN LA RIITS
APPENDIX F – SUMMARY OF STANDARDS FOR LOS ANGELES ATIS PROJECTS
APPENDIX G – EXAMPLES OF PERFORMANCE REPORTS
APPENDIX H – STARNET AS ENVISIONED AND DESIGNED
APPENDIX I – CURRENT STARNET (AS BUILT)
APPENDIX J – INDUSTRY REVIEW
APPENDIX K – LIST OF DOCUMENTS PROVIDED BY STARNET STAKEHOLDERS
APPENDIX L – EMERGING NEEDS OF TARNET STAKEHOLDERS

LIST OF FIGURES

Figure 1 - Map of Sacramento Region 5
Figure 2 - Outreach Materials by FDOT / SunGuide D2
Figure 3 - Training Material Developed by NDOT D3
Figure 4 - Nevada Training Brochure for Incident Response Training D4
Figure 5 - Flordia SunGuide: Arterial Level Performance Measures G2
Figure 6 - STARNET Proposed Major Information Flows H2
Figure 7 - STARNET System Architecture (Provided by Castle Rock) I1
Figure 8 - STARNET Data Sources and Interfaces I3
Figure 9 - STARNET CARS Interface I4
Figure 10 - Current CARS Architecture on AWS Platform I5
Figure 11 - CARS-Hub with a List of Available Data Feeds I7
Figure 12 - STARNET Interfaces Tracked with Google Analytics I8
Figure 13 - Google Analytics: STARNET Operator Interface Usage Statistics I11

LIST OF TABLES

Table 1 - STARNET Assessment Approach 8
Table 2 - STARNET Feedback Summary and Impact on Program Goals 12
Table 3 - Gap Analysis Scoring Methodology 15
Table 4 - Summary of the Current Status of STARNET Goals 16
Table 5 - Status of Originally Conceived STARNET Goals 17
Table 6 - Agency Challenges 18
Table 7 - STARNET Technical Pain Points 19
Table 8 - Summary of STARNET Recommendations and Proposed Activities 23
Table 9 - Recommendation Execution Timeline 32
Table 10 - STARNET Data Types 31
Table 11 - Feedback Received during Kick-Off from Multiple Agencies B2
Table 12 - Computer Systems and Status C1
Table 13 - Proposed CCTV Camera Implementation Plan C3
Table 14 - Types of Agreements Used in LA RIITS E1
Table 15 - Summary of Standards of Los Angeles ATIS Projects F1
Table 16 - Quarterly Performance Measure Standard G1
Table 17 - Major Stakeholders / Data Providers for STARNET H3
Table 18 - Transportation Management Systems and Data Provided H5
Table 19 - STARNET Modules and Interfaces I2
Table 20 - STARNET Hosting Environment I4
Table 21 - 511 Call Volume: April 2017 - March 2018 (Active Agencies) (Source: Castle Rock) I9
Table 22 - CARS (all interfaces) Usage by Agency (Source: Castle Rock) I9
Table 23 - STARNET Usage Statistics I10
Table 24 - SunGuide Software Features J5
Table 25 - SunGuide Current Count of ITS Devices Per Category J6
Table 26 - List of Documents Provided by SACOG Stakeholders K1
Table 27 - Emerging Needs of STARNET Stakeholders L1

LIST OF ABBREVIATIONS

AMBER – America's Missing Broadcast Emergency Response
API – Application Program Interface
ATIS – Advanced Traveler Information System
ATMS – Advanced Traffic Management System
ATSPM – Automated Traffic Signal Performance Measures
AVL – Automated Vehicle Location
AWS – Amazon Web Service
C2C – Center-to-Center
CAD – Computer-Aided Dispatch
CARS – Condition Acquisition and Reporting System
CCTV – Closed Circuit Television
CHP – California Highway Patrol
CMS – Changeable Message Sign
CHP – California Highway Patrol
CAV – Connected/Autonomous Vehicles
DMS – Dynamic Message Sign
DOT – Department of Transportation
EM – Emergency Management
EOC – Emergency Operations Center
EV – Electric Vehicle
FL511 – Florida 511
GTFS – General Transit Feed Specification
IEEE – Institute of Electrical and Electronics Engineers
IEN – Information Exchange Network
ISP – Internet Service Provider
IT – Information Technology
ITS – Intelligent Transportation System
KPI – Key Performance Indicator
LCS – Lane Control System
MAS – Management and Analytics System
MMS – Maintenance Management System
MOU – Memorandum of Understanding
O&M – Operations and Maintenance
PeMS – Performance Measurement System
RIITS – Regional Integration of Intelligent Transportation Systems
RPD – Regional Planning Database
RTIS – Regional Travel Information System
SAA – Systems Application Architecture
SACOG – Sacramento Area Council of Governments
SEMP – Systems Engineering and Management Plan
SOP – Standard Operating Procedure
STARNET – Sacramento Transportation Area Network
TMC – Traffic Management Center
TMDD – Traffic Management Data Dictionary
TMS – Traffic Management System

EXECUTIVE SUMMARY

What is STARNET?

STARNET stands for the Sacramento Transportation Area Network. STARNET is an information exchange network that shares real-time traffic data and live video between transportation providers, Transportation Operations Centers, and emergency responders. STARNET also refers to the institutional infrastructure, including communications, joint procedures, and information technology required to better coordinate the activities of participating agencies. STARNET data helps inform the public, who access it through the Sacramento region 511 transportation information service.

STARNET's mission is to improve traffic flow and reduce vehicle emissions in the Sacramento region by coordinating intelligent, multi modal real-time transportation data to make travel easier for all users, from commuters to emergency responders.

The purpose of this report is to assess the state of the STARNET system and evaluate STARNET as a data information exchange network for transportation managers, Transportation Operations Centers (TOCs) and emergency responders in the Sacramento region. SACOG's objective is to determine whether STARNET is still a reliable, usable and effective conduit for regional data gathering and real-time information and video sharing. This report addresses the following issues:

- Determine if STARNET met its originally established goals.
- Identify and analyze which specific goals were not met
- Update the original STARNET goals to reflect new business needs.
- Identify technological and institutional changes to be made to STARNET to address new or revised user needs and updated goals due to the changing business environment,
- Determine the level of engagement and coordination expected from agency operators and their expectations from SACOG in order to adapt, operate and maintain STARNET to its fullest capacity.
- Recommend an approach to meet those unmet goals.

To understand the current state of STARNET the Project Team performed an in-depth review of the original engineering and design documents, including the Concept of Operations, System Requirements, System Engineering Management Plan, and the Condition Acquisition and Reporting System (CARS) training manual. These documents contained extensive information regarding STARNET needs, operating use cases, user needs, system requirements, system management plans, and details of STARNET as it is currently implemented. To further evaluate the current state, SACOG facilitated a detailed interview process with major stakeholders, including Castle Rock, Caltrans District 3, and the City and County of Sacramento. These interviews were a valuable source of user feedback on the details of the day-to-day operations. The Project Team also collected user feedback during workshops and meetings, and meeting minutes from historical meetings and other peripheral documents shared by stakeholders. These interactions provided valuable user perspectives, recommendations, and an understanding of the sources of user satisfaction or frustration with the current system.

The Project Team conducted an industry review to analyze how systems in other states and regions are addressing similar goals. This analysis helped the Project Team to acquire lessons and best practices, which informed the future direction for STARNET.

We developed STARNET's vision for the future by comparing STARNET with other major regional systems including a large metropolitan area, the Los Angeles Metro, and a statewide system, SunGuide of Florida. These two systems are widely considered successful in achieving their goals and objectives. We conducted a detailed review of documents provided by these systems to answer some basic questions as they pertain to STARNET, including:

- What are the goals and objectives of the systems;
- What features and functionalities do the systems provide to participating agencies as well as public users; Focus on the functionalities provided and not how the functionality is implemented.
- What are the lessons learned from the deployment of each system;
- What is working or not working for the system; This can come either through documents or from our own judgement or from conversations with people.
- Are there any technological approaches (virtualization, clouds, etc.) that can be brought into STARNET;
- What new datasets, if any can be implemented in STARNET; and
- How is the Center-to-Center (C2C) implemented?

A detailed review of such large complex systems and lessons learned from their deployment, along with user feedback and a detailed GAP analysis, formed the basis for developing the recommendations that SACOG should implement to ensure STARNET remains a viable system for the future. The review of other systems included their own goals and objectives, the maturity of the technology deployed, future plans, the complexity of the database and the areas served. The review of these systems allowed for direct and indirect comparison to the overall goals and objectives of STARNET. As in with every other major system, the recommendations address technical and business changes that should be implemented. Some of the key recommendations for STARNET are as follows:

- ***Establish STARNET Program:*** Operate STARNET as a program with a dedicated budget and resources. Developing a program around STARNET would involve appointing a program manage, allocating short-term and long-term budgets, developing and monitoring specific performance measures, and assigning clear roles and responsibilities for SACOG and other member agencies.
- **STARNET Outreach Plan: Create outreach and communication plans.** An outreach program should be developed for partner agencies **to** inform them of **new updates to** STARNET and how it benefits them. An outreach program for the travelling public should also be developed.
- **Enhance Infrastructure**: Enhance, expand, operate, and maintain the infrastructure needed to provide fast and reliable regional communication and real-time information sharing. Development and maintenance of a comprehensive infrastructure inventory, operations, and maintenance plans that are standard and easily shared among the partner agencies. This will also allow STARNET to establish and monitor baselines for system and network utilization.
- **Provide assistance to partners**: Assist agencies to integrate and operate STARNET. Agencies need to be able integrate STARNET within their daily operations. Agencies will need support in detailed training documents and technical guidance at every stage of development. Management commitment with allocation of resources will also assist in the overall integration effort.

- **Develop institutional processes** for regional transportation operations and emergency response. As STARNET serves a regional system, it is important to establish a clear set of standard operating procedures and use cases. Regional information can allow for actionable information based on predictive analysis.
- **Integrate data from various transportation modes and systems:** The system must be made capable of integrating multi-modal data points and these should be prioritized based on use cases. Much of the data should also be automatically imported into the system.
- **Facilitate data and video sharing among partner agencies:** STARNET should utilize a standard data format that can be used by all partner agencies. This data exchange should be able to translate both through importing and exporting data to and from STARNET. This will require coordination between the various agencies. Regionally the agencies will have to agree on a format that is compatible with STARNET and feasible for local areas.
- **Enable real-time access and control of field devices.** Connected field devices can allow for remote activation during times of emergency. Real-time access will allow operators to activate devices remotely to facilitate smoother response times and more efficient vehicle travel.
- **Develop and distribute data analytics:** By establishing a regional database and data governance standards, it would be possible to develop data analytics plans and dashboards for visualization to provide predictive analysis of patterns on a regional level.

INTRODUCTION

STARNET Background

The Sacramento Transportation Area Network, or **STARNET**, is an information exchange network and operations coordination framework that was implemented from 2009-2011 to assist operators of transportation facilities and emergency responders within the Sacramento region, and to launch the region's 511 and traveler information services. STARNET was developed to enable real-time sharing of data and live video, the refinement of joint procedures pertaining to the operation of roadways and public transit, and public safety activities. STARNET also represents the physical and institutional infrastructure, including communications and Information Technology (IT) systems, required to better coordinate the activities of participating agencies. The development of STARNET is key to regional traffic management as it integrates real-time information about the condition of the transportation system while assisting traffic and emergency management staff across local and jurisdictional boundaries.

STARNET was built upon previous Intelligent Transportation System (ITS) investments by using data from the existing field infrastructure and central systems of the agency partners. The existing infrastructure included cameras, changeable message signs, traffic signals, vehicle location systems, and central systems such as freeway management systems, traffic signal systems, transit management systems, computer aided dispatch systems, and so forth. STARNET was developed to enable agencies to seamlessly share data and video with each other, provide data and video to the public via the 511-regional travel information system, and provide operations and emergency response personnel with a map-based, regional transportation management user interface.

The STARNET team is comprised of the Sacramento Area Council of Governments (SACOG); SACOG's system integrator, Castle Rock; and stakeholder agencies. SACOG is the sponsor of STARNET and funds the project. Castle Rock designed and implemented STARNET's system and software. Castle Rock is responsible for the operations and maintenance of STARNET. STARNET is led by the Sacramento Region ITS Partnership, which designates a STARNET Technical Advisory Committee. The following agencies are part of the STARNET team and provide and/or receive data on STARNET:

- California Highway Patrol
- Caltrans District 3
- El Dorado County
- El Dorado County Transit Authority
- Placer County
- Sacramento Area Council of Governments
- Sacramento County
- Sacramento Regional Fire/EMS Communications Center
- Sacramento Regional Transit District
- Yolo County Transportation District
- Yolo County Communications Emergency Service Agency
- City of Citrus Heights
- City of Elk Grove
- City of Folsom
- City of Rancho Cordova
- City of Rocklin
- City of Roseville
- City of Sacramento
- City of West Sacramento

Figure 1 shows overview of Sacramento region, referenced from STARNET Concept of Operations document.

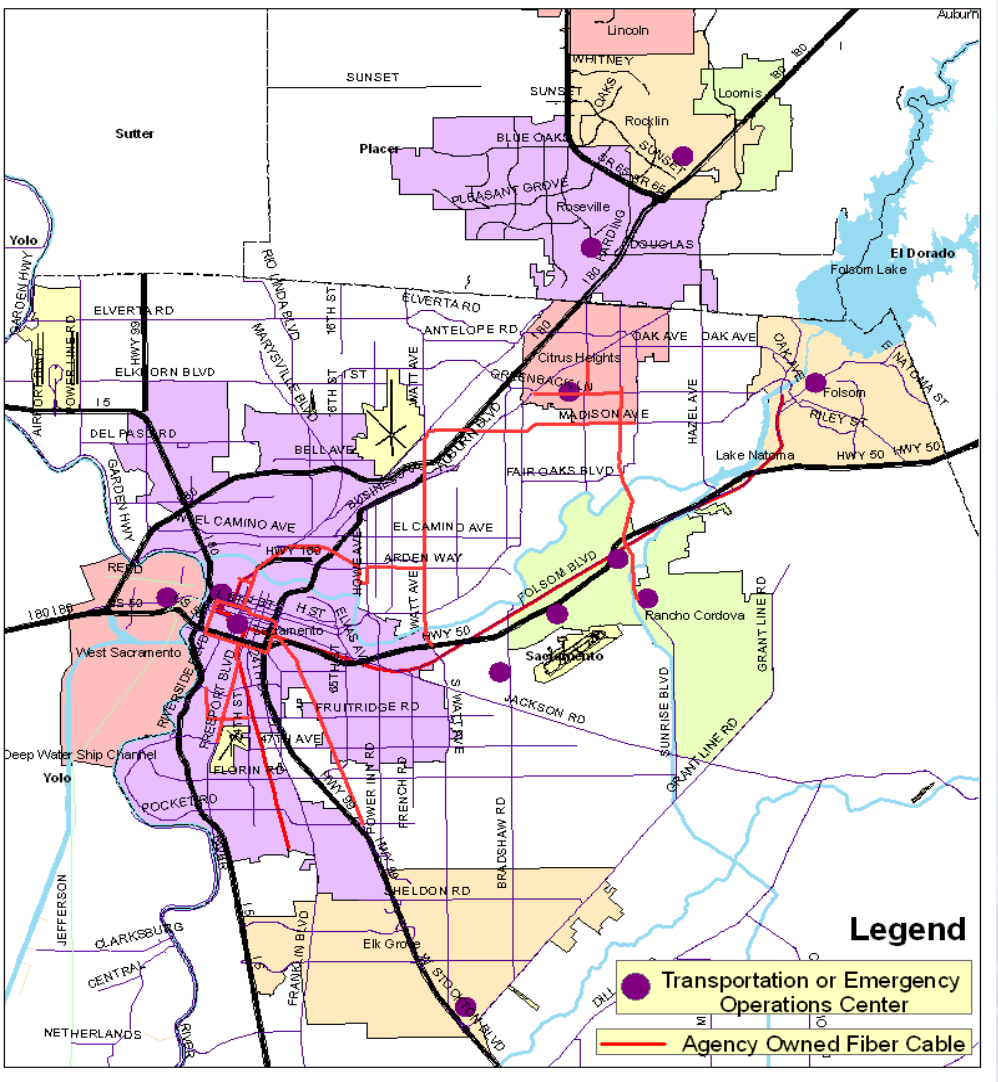

Figure 1 - Map of Sacramento Region

Purpose and Goals of STARNET

SACOG summarizes the purpose of STARNET as follows:

The purpose of STARNET is to enable real-time data and live video pertaining to the operation of roadways and public transit, to be shared between computers and people involved in transportation operations and emergency response in the Sacramento region, thereby assisting in the coordination of their activities and assisting in providing the public with a regionally focused source of comprehensive information about current travel conditions and options (511). STARNET is also intended to provide improved integration of operation procedures, including procedures that take advantage of the data and video sharing capabilities of STARNET and facilitate improved emergency response.

Using the reference documents and the purpose stated above, the following were the goals for STARNET:

• Facilitate the creation and the exchange of data in real time among agencies **(A1)**
• Make data available for the regional 511 system **(A2)**
• Develop procedures that enhance coordination among agencies **(A3)**
• Enhance the effectiveness of real-time transportation management, operations, and emergency management **(A4)**
• Enhance the effectiveness of regional and local transportation planning **(A5)**
• Build, operate, and maintain a STARNET system per STARNET system requirements to facilitate the achievement of goals A1-A5 **(A6)**

These goals, each of which are described further below, are referenced by number (A1, A2, etc.) throughout the document for easier cross-referencing. STARNET's performance will be evaluated based on these goals.

A1. Exchange Data in Real Time Among Agencies:

The Concept of Operations identified that the following types of data shall be exchanged on STARNET and made available to operators on the operator interface:

- Incidents, including planned lane closures;
- Changeable message sign content;
- Traffic signal status;
- Vehicle detector data;
- Transit service disruptions;
- Automated vehicle location data;
- Transit vehicle arrival time;
- Ramp metering status; and
- Video and camera control.

A2. Make Data Available for the Regional 511 System:

A filtered subset of the available data and live video (without camera control) will be provided to the regional travel information system where the data can be incorporated into a publicly accessible web page and the 511-phone system.

A3. Develop Procedures that Enhance Coordination Among Agencies:

To realize the full benefits of STARNET and enable information exchange among partner agencies, STARNET will help develop procedures to enhance the coordination of activities between agencies. The procedures will focus on how to include STARNET and its data and capabilities into agencies' existing operating procedures.

A4: Enhance the Effectiveness of Real-Time Transportation Management, Operations, and Emergency Management:

Through the combination of data sharing and improved operating procedures, STARNET will enhance the effectiveness of transportation management and emergency response in the following ways:

- **Real-time Information:** Provide additional real-time information, including live video from roadside cameras needed for operations personnel and emergency responders to make informed and effective decisions.

- **Unified Information View:** Provide information exchange, a map-based, integrated view of data from all agencies, and joint procedures needed for agencies to better coordinate their activities.
- **Regional Incident Information:** Provide more comprehensive, accurate, and timely information to the public concerning the status of transportation facilities and incidents.
- **Enhanced Coordination:** Enable better coordination of transportation management and emergency response activities during major emergencies, such as flood evacuations.
- **Data Exchange Automation:** Provide the data exchange needed between computer systems to enable automated coordination of traffic signal timings across jurisdictional boundaries even when using traffic responsive pattern selection.
- **Support Regional Modeling and Evaluation:** Enable automated collection of compatible data from all agencies for use in regional transportation modeling and performance evaluation programs.

A5: Enhance the Effectiveness of Regional and Local Transportation Planning:
Collect and use data from STARNET for transportation planning purposes, including preparing various short- and long-term planning scenarios.

A6: STARNET Implementation and Maintenance:
Build STARNET and provide technical assistance and training to the partner agencies in installing and operating. This work is performed by SACOG's system integrator, Castle Rock.

Approach

In order to assess the state of STARNET using the key questions from SACOG as a guide, the following approach was followed to assess need for STARNET and to recommend actions to be taken to make STARNET a strategic tool for SACOG to achieve its regional transportation goals. High level steps are described in **Table 1**. These steps are further described below:

Review Designed and Current STARNET: In order to understand the original intent of the STARNET project, we reviewed the documents listed below, which were made available by SACOG and Castle Rock:

1. STARNET Concepts of Operations V 1.0 (June 23, 2006)
2. STARNET Systems Requirements V1.0 (October 29, 2007)
3. STARNET Systems Engineering Management Plan V1.0 (February 14, 2006)
4. CARS5 Training Document (Condition Acquisition and Reporting System)
5. Signed - Multi-2017-02_2017-18 CARS and CARS-511 MO Plan
6. STARNET Presentation Castle Rock -- September 2018 kv2

These documents contain extensive information regarding STARNET needs, operating use cases, user needs, system requirements, system management plans, and details of STARNET as it is currently implemented. In further evaluating the current state, the Project Team undertook a detailed interview process, facilitated by SACOG, with major stakeholders, including Castle Rock, Caltrans District 3, and the City and County of Sacramento. We used this information to assess the current state of STARNET as described in the ***Appendix H - STARNET as Designed and Envisioned*** and ***Appendix I - Current STARNET*** sections of this document. Many other documents related to STARNET were shared by stakeholders after this document was developed. Those documents are listed in Appendix K.

Table 1 - STARNET Assessment Approach

Review Designed and Current STARNET	• Original goals set for STARNET were reviewed against the implemented STARNET. • Concept of Operations, Systems requirements documents were used to develop an understanding of designed STARNET. • Documents provided by SACOG's system integrator including STARNET demo were used to develop understanding of currently implemented STARNET.
Analyze User Feedback and Emerging Needs	• Original user needs that led to the development of STARNET were analyzed to understand the existing system's intent. • User feedback from various meetings was used to identify new needs or changes to the original needs.
Prepare Gap Analysis	• Gap analysis was conducted to determine whether STARNET has met the original goals set in the Concept of Operations document developed in 2006. • In addition, gaps in current and anticipated usage of STARNET by participating agencies was also analyzed.
Conduct Industry Review	• Regional and state level systems similar to STARNET were studied as part of this analysis. • Lessons learned from these implementations, which are relevant to STARNET, are compiled to develop a vision for future STARNET.
Vision and Recommendations	• The vision for future STARNET and recommendations to achieve that vision is presented based on gap analysis and industry review. • Future vision addresses current shortcomings of STARNET, new needs expressed by users, and changes in operating environment for stakeholder agencies.

Analyze User Feedback and Emerging Needs: User feedback remains a valuable tool in this assessment, and was gathered in following formats:

1. Direct communication during workshops, meetings and calls
2. Meeting minutes from historical meetings that took place between partner agencies and KHA
3. Documents shared by the stakeholders

These interactions have provided us with valuable user perspectives, recommendations, and an understanding of the sources of user satisfaction or frustration with the system. The objective of this document is to organize existing information while analyzing new information to provide meaningful insight into the current state of STARNET and its ability to meet the goals established by SACOG and its partner agencies. User feedback is detailed in section named "Stakeholder Feedback and Changes in Needs"

Prepare Gap Analysis:
Based on the document review, interactions with the stakeholders and feedback gathered from the partners, we prepared a gap analysis. The following steps were taken in preparation of gap analysis:

1. STARTNET goals (A1-A6) were evaluated against available information and marked as partially complete, complete or incomplete.

2. These gaps in achievement levels of STARNET goals were further analyzed and presented as a list of pain points faced by SACOG as well as partner agencies.

The gap analysis, along with industry review, user feedback, emerging needs of users and current STARNET implementation were then used to develop recommendations.

Conduct Industry Review: We conducted an industry review to analyze how systems in other states and regions are addressing similar goals. The lessons and best practices we learned from this helped determine the future direction for STARNET.

We developed STARNET's vision for the future by comparing STARNET with other major regional systems including a large metropolitan area, the Los Angeles Metro, and a statewide system, SunGuide of Florida. These two systems are widely considered successful in achieving their goals and objectives. We conducted a detailed review of documents provided by these systems to answer some basic questions as they pertain to STARNET, including:

- What are goals and objectives of the systems
- What features, and functionality does the system provide
- What are lessons learned from the systems for STARNET
- What is working or not working for the system
- Are there any relevant technological approaches (virtualization, clouds, etc)
- What new datasets, if any can be implemented in STARNET?
- How is Center-to-Center (C2C) implemented in this system?

Vision and Recommendations:
Based on the review, along with the understanding of the current STARNET, our vision and recommendations are developed and presented in section named "New STARNET: Vision and Recommendations". A high-level execution plan to implement the recommendations is also included at the end of the section.

STAKEHOLDER FEEDBACK AND CHANGES IN NEEDS

Throughout this project, we collected feedback from multiple agencies on their use of STARNET and their growing and changing needs compared to the original STARNET needs. We have summarized their feedback below. This feedback was collated from multiple meetings with SACOG's partner agencies. Staff responsible for Traffic Operations Center (TOC), Traffic Management Center (TMC), and STARNET participated in the meetings, which took place from March to September of 2018.

Much of the feedback flowed from direct discussion about the key STARNET questions posed by SACOG (as mentioned in the ***Introduction*** section and summarized in **Appendix A**), while other pieces of feedback were gathered through indirect conversations about STARNET expectations versus the current state. For example, during discussions about the Concept of Operations, stakeholders expressed the need for data in order to manage regular traffic incidents as well as emergencies. Such indirect feedback was also considered important as it points to a need that STARNET is capable of meeting even though it is not doing so at present.

The following section summarizes the major feedback received and issues raised during meetings with stakeholders. **Appendix B** lists all the major points raised in each meeting.

Feedback Summary

We have categorized the feedback received in the following ways:

1. **Feedback from SACOG:** Feedback received from SACOG provided the perspective of a regional agency that is interested in promoting regional transportation operations and management in the short and long-term.
2. **Feedback from Agencies Regarding the Current System:** In this subsection, benefits of the STARNET and challenges faced by agencies are listed. The benefits or challenges are technical or organizational in nature.
3. **Feedback from Agencies Regarding Additional Expectations from the Current System:** In this subsection, current and future needs from STARNET are listed. These needs will be used to enhance the vision of STARNET and to provide recommendations to achieve it.

This process revealed multiple issues that can be grouped together to facilitate gap assessment and the development of recommendations. Many agencies shared issues that were interdependent. Thus, if an issue is not addressed promptly, it may aggravate other issues.

Feedback from SACOG: SACOG faces a challenging environment as several agencies are not subscribing to or using STARNET at the anticipated rate. SACOG is funding the operations and maintenance of STARNET, knowing that many operators are not actively using it. SACOG is encouraging agencies to work on STARNET and providing training, but with limited returns on it efforts. SACOG has provided extensive feedback. Main points raised in the feedback are listed below.

1. **Communication with agencies**: In the beginning of the project SACOG contacted all the agencies and received commitment from most of them. However, during the data gathering process, SACOG had challenges in finding responsible people within the agencies for providing data to STARNET. Even when such contacts were identified, often it had been difficult to get a response back.
2. **Training and assistance:** STARNET training has been provided to many agencies. SACOG hired full-time staff to help agencies with STARNET and hired contractors to provide technological help to

agencies in integrating their data with STARNET. SACOG maintains records of the assistance it has provided to agencies. When SACOG and/or Castle Rock provide additional help, the agencies do not follow through on their tasks, such as testing.

3. **Challenges in Adapting STARNET:** Each agency handles situations in a unique way, and many agencies are not clear on how to fit STARNET into their operations. SACOG has extended various types of assistance to encourage stakeholders to adopt STARNET; however, SACOG has not seen a reciprocation or adaptation of STARNET by stakeholders.
4. **Resource Challenge:** Agencies are understaffed and cannot allocate resources to operate and provide data on STARNET.
5. **Buy-in on Vision:** It is observed that agencies are not focusing on the long-term vision of data-sharing with other agencies and SACOG. Agencies need to understand their responsibility in that regard and improve sharing data. There is an urgent need to engage the management of stakeholder agencies so that data-sharing at the regional level becomes a priority. SACOG maintains that sharing transportation data regionally should be a priority for agency management.
6. **Operating Challenges:** SACOG understands that agencies have experienced problems and/or difficulties using the tool.
7. Based on SACOG's experience with STARNET and stakeholder participation, SACOG is willing to take STARNET in the direction desired by participating agencies.
    1. Continue funding if agencies are finding STARNET useful and are committed to using STARNET
    2. Improve STARNET if additional features and functionality are expected
    3. Stop supporting STARNET altogether if there is no need or no desire to use

Feedback from Agencies Regarding the Current System:
Benefits of STARNET:

1. SACOG's system integrator has implemented STARNET and provided multiple interfaces to operators and the public to access transportation information. These tools allow operators to load various data sources, including incidents, CMS, road closure, transit data, and other sources mentioned in the Current STARNET section.
2. STARNET's Modes modules have enabled smaller agencies to develop and maintain their GTFS and GTFS-real-time data sets.
3. Once the Integrated Corridor Management has been implemented, STARNET could become the backbone for inter-agency communication.
4. STARNET data is integrated with the 511-phone system, which is accessed by an average of 10,000–11,000 people every month and exceeds the usage reported by other state agencies using CARS.

Table 2 presents agency feedback grouped by categories. We believe this direct and indirect feedback sheds light on why STARNET is not or cannot be used by the agencies.

Table 2 - STARNET Feedback Summary and Impact on Program Goals

Feedback from Stakeholder	SACOG's Goals Largely Impacted by Issue Highlighted					
	A1	A2	A3	A4	A5	A6
	Inter-Agency Data Exchange	Data for Public	Enhance Inter-agency Co-ordination	Enhanced Transportation Management	Enhanced Planning	STARNET System
Dedicated Resources to Operate and Maintain STARNET:						
Due to staffing constraints agencies are not able to provide dedicated resources to operate and update STARNET regularly.	✓	✓	✓	✓		
Ability of agencies to attend trainings, interact with SACOG, and to work with SACOG's system integrator to integrate data sources.	✓	✓				
As there are no trained resources within the organization, small issues during operations result in big obstacles.	✓	✓		✓		
Lack of management commitment to allocate resources to operate STARNET	✓	✓	✓	✓		
Agencies do not have commitments to provide dedicated staff who can get trained and serve as champions of STARNET to then lead STARNET use within their organizations.	✓	✓	✓	✓		
Data and Systems at each agency:						
Agencies have multiple sources of data. They need more training so that they can determine which data to share, and then work with SACOG on the process of sharing.	✓	✓				
Agencies need assistance in determining which of the datasets would be useful for other local and regional agencies.	✓	✓				
Agencies are uncertain about the privacy of data once they share it with STARNET. They expect to have clear policies around ownership, sharing, and distribution once data leaves	✓	✓	✓			

Feedback from Stakeholder	SACOG's Goals Largely Impacted by Issue Highlighted					
	A1	A2	A3	A4	A5	A6
	Inter-Agency Data Exchange	Data for Public	Enhance Inter-agency Co-ordination	Enhanced Transportation Management	Enhanced Planning	STARNET System
their system and goes to STARNET.						
Agencies have multiple systems for ATMS, TMS, DMS, etc. and STARNET becomes an additional system to operate.	✓	✓				
Agencies are tasked with inputting data manually in STARNET, which is not efficient.	✓	✓				✓
Agencies still rely on legacy infrastructure and other sources rather than relying on STARNET	✓	✓	✓	✓		
It is difficult and time consuming to integrate data sources with STARNET. Agencies do not have bandwidth to allocated extended time. CARS is state DOT oriented and so far, integration with Cities and Counties is not smooth.	✓	✓	✓	✓		✓
Inability of STARNET to gather and integrate information published at other places (local road closures at county's website)	✓	✓	✓			✓
Standardized Operating Processes:						
Each agency has a unique way they handle situations and many agencies are not clear on how to fit STARNET in their operations. Also, many agencies need to know how using STARNET will benefit them in fulfilling their regular responsibilities.			✓	✓		
Communication with other agencies:						
Even though STARNET provides users the ability to view data submitted by other agencies, STARNET is not considered a reliable/secure	✓		✓	✓		

Feedback from Stakeholder	SACOG's Goals Largely Impacted by Issue Highlighted					
	A1	A2	A3	A4	A5	A6
	Inter-Agency Data Exchange	Data for Public	Enhance Inter-agency Co-ordination	Enhanced Transportation Management	Enhanced Planning	STARNET System
means to communicate with other agencies or to exchange data with other agencies.						
SACOG-Agency Memorandum of Understandings (MOU):						
There are no clear MOUs between SACOG and stakeholders which requires stakeholders to use STARNET. Also, SACOG depends on co-operation from the agencies. However, lack of understanding of roles and responsibilities as well as accountability, the co-operation has not been satisfactory for SACOG.	✓		✓			
Technical issues with STARNET:						
Some agencies have reported that they attempted to use 511/STARNET but have found inherent issues with mapping and information.	✓	✓				✓

Feedback from Agencies Regarding Additional Expectations from the Current System:
Agencies identified the need for different types of data that are not made available via STARNET today. Also, they have expressed needs that are not technical, but will help them in operating and maintaining STARNET. Finally, they have shared what new technologies and data sets they would like to have to solve their local/jurisdictional needs. This feedback is summarized and is presented in Appendix L.

GAP ANALYSIS

The objective of this gap analysis is to compare the current performance of STARNET with how it was designed to perform. Two documents were used as benchmarks for this analysis:

1. System requirements as listed in STARNET System Requirements document.
2. Program level goals as listed in STARNET Concept of Operations document.

The STARNET gap analysis shows how well the current system adheres to the goals it was expected to meet. At the time of development, multiple goals and requirements were listed for STARNET. These were:

- Goals A1-A5 as described in the ***Introduction*** section.
- System requirements (A6) such as how the system should be built, what functionality it should provide, level of availability, level of support expected, etc. This is also represented as goal A6.

Among the goals, only system related requirements could be quantitatively evaluated. Document review, input from user feedback, meetings with SACOG and SACOG's system integrator, and meeting with other stakeholders were various methods used to determine the status of all goals.

In order to conduct the gap analysis, all STARNET goals and requirements have been listed in **Table 4** along with a status update. By reviewing the expectations versus current status in this table format, we can identify gaps in the current system. The information has been inferred from the input provided by stakeholder agencies, SACOG, SACOG's system integrator and list of documents made available as indicated in the ***Reference*** section.

As clear performance metrics were not developed for most goals for STARNET, evaluating the success of each goal poses a challenge, since no baseline for evaluating STARNET was established. This analysis was conducted using all available information including STARNET demonstration provided by Castle Rock. In order to represent the status of each goal, a relative scale was used to be able to show the gaps between originally conceived goals and actual status. This scale was given a range in order to represent different statuses for different goals. The status of each goal is captured compared to its baseline. This scale acts as a number line with the baseline in the middle, marked as zero. When the requirements or goals are met, as defined or expected or specified, baseline is considered to be met and score of zero is assigned. When a requirement or goal is partly met, a score of -1 is given, and when the requirement or goal is not met or very minimally met, it is given a score of -2. Similarly, when a requirement or goal is exceeded, score of +1 is given. For example, if a system is specified to provide a response time of 3 seconds or less, but provides a response time of 1 seconds, a +1 score will be assigned.

Table 3 - Gap Analysis Scoring Methodology

Status Indicator	Meaning
-2	When performance is considerably lower than expected or when requirement/goal is not met
-1	When performance is lower than expected or requirement/goal is partially met.
0	At baseline, when performance is as expected or when requirement/goal is met.
+1	When performance is more than expected or requirement/goal is met and exceeded.

Summary of Gaps

Table 4 summarizes the STARNET goals.

Table 4 - Summary of the Current Status of STARNET Goals

STARNET Requirements and Purpose	Status of Completion of Goal or Requirement	Program Goal	Information Used to Determine Status
High-level Program Goals			
Exchange of real-time data among all SACOG partner agencies	-1	A1	About 18 agencies, as mentioned in the introduction section, were originally expected to provide data to STARNET. However, currently only five agencies are providing traffic management data and four transit agencies are working with SACOG to provide transit data.
Availability of STARNET data for regional 511 systems/number of systems currently connected using STARNET (COP Sec.5)	0	A2	At least 26 systems were expected to be connected in the first implementation of STARNET; of them, only nine have been implemented, as described in **Appendix C**.
Provide the public with a regionally focused source of comprehensive information about current travel conditions and options.	0	A2	SacRegion 511 is a multi-channel, regional 511 system. Through SacRegion 511, the traveling public receives data sources from STARNET. SacRegion allows travelers to track current road conditions and make mode choice options.
Availability of detailed procedures to enhance coordination among agencies	-2	A3	Many agencies have indicated that they are unaware of what is expected from them and that they are unaware of the standard operating procedures (SOPs) for using STARNET and exchanging data with other agencies.
Enhancement in the effectiveness of real-time transportation management (operations and emergency management) and planning.	-2	A4	No direct data from either SACOG or participating agencies are available to evaluate these goals. However, only up to five agencies are actively using STARNET and data from only a few stakeholders is available in STARNET, this goal is considered to be minimally met.
Number of stakeholders currently using STARNET (COP Sec.4)	-2	A1, A2	Based on feedback from SACOG, Castle Rock, and agencies, it is estimated that only five - seven agencies login and access or provide data to STARNET even though STARNET has 100+ user accounts.
System Requirements			
Data source/sink requirement	-2	A1, A2, A6	At least 26 systems were expected to be connected in the first implementation of STARNET; of them, only 9 have been implemented, as described in **Appendix C**.
CCTV requirement	-1	A1, A2, A4, A6	According to COP, at least 190 CCTV cameras were expected to be available in the first implementation of STARNET. Visual inspection of the Sacramento 511 shows only 80, so, this goal is considered to be partially met.
Architectural requirements	0	A1, A2, A6	Based on the system architecture requirements listed in the STARNET System Requirements document, this goal is met.
Hosting requirements	0	A1, A2, A6	Based on the hosting requirements listed in STARNET System Requirements document, this goal is met.
Object requirements	0	A1, A2, A6	Based on the object requirements listed in the STARNET System Requirements document, this goal is met.
Message requirements	0	A1, A2, A6	Based on the message requirements listed in the STARNET System Requirements document, this goal is met.
Interface requirements	0	A1, A2, A6	Based on the interface requirements listed in the STARNET System Requirements document. Few additional interfaces are also made available, such as interfaces to build GTFS data for transit agencies, interfaces to gather real-time information, etc.

Functional requirements	-1	A1, A2, A6	A high-level pass/fail review of the STARNET System Requirements document based on our understanding of the operator interface (as shown in demo) and 511 public interfaces
Planning database	-2	A5	A planning database was expected to be set up by SACOG to save data from STARNET. This data was then planned to be used for short- and long-term regional planning purposes. The database was not developed.
STARNET O&M Goals			
STARNET system availability/accuracy/currency of data	0	A1, A2	No information is available regarding STARNET uptime or downtime.
STARNET system security	0	A6, A6	Per the Castle Rock O&M document, this requirement is met.
STARNET training	0	A3, A6	Per our conversations with SACOG, this requirement is met. SACOG and Castle Rock have provided multiple training sessions for agencies.
STARNET technical support	0	A6	Per Castle Rock, this requirement is met.

Based on the results shown in **Table 4, Table 5** provides detail on the program goal's status. The Reasoning column provides context of why the Goal was either Partially Met or Not Met.

Table 5 - Status of Originally Conceived STARNET Goals

Program Goal	Overall Status	Reasoning
A1	**Partially met**	More than 100 user accounts have been created for the CARS interface. As a result, there are a small number of active sessions every month and some data has been exchanged between agencies.
A2	**Partially met**	Even though all planned datasets are not being automated, STARNET has automated many data sets, such as CAD from CHP, Caltrans LCS data, Caltrans CMS data, PeMS traffic detector data, WAZE data, and video streams from 80+ CCTV cameras. This data is available on 511 and makes it a very useful site. Additionally, this data is also available on 511 phone, which has one of the highest use among the CARS users.
A3	**Not met**	Inter-agency coordination is not reported, and agencies are not sharing data or accessing each other's data using STARNET. This does not mean that agencies are not coordinating; rather, it only shows that STARNET is not used as the preferred system of coordination and/or data exchange.
A4	**Not met**	No measurable impact was reported in the improvement of transportation operations and/or emergency management due to STARNET.
A5	**Not met**	SACOG has not established a planning database; therefore, this goal is considered to not be met.
A6	***Partially Met***	***Though the STARNET system is designed, developed, operated, and maintained, some requirements such as CCTV control, ramp meters, and traffic signal integration has not happened due to limits on existing systems and data-sharing capabilities. However, SacRegion 511 is an established a multi-channel, regional 511 system that provides valuable traveler information to the public. Hence this program goal is considered to be partially met. Specific requirements within the goal are tracked separately in Table 8.***

Analysis of Gaps

From **Table 4**, it can be inferred that STARNET has partially met its requirements and goals. In this section, we will analyze the reasons behind these gaps based on reference documents and user feedback captured in the ***Gap Analysis*** section and **Appendix B**.

As mentioned earlier, STARNET's program goals are interdependent and hence collectively affect all program goals. Only program goal A6 is not directly affected. This is because this goal is about design, development, operation, and maintenance of STARNET, which is managed by SACOG and executed by Castle Rock. SACOG has direct control over the monitoring and control of this goal. All other goals are highly dependent on the participation and engagement of partner agencies. The participation of partner agencies further depends on and is reported to be affected by the following factors.

Operating Environment

SACOG partner agencies are responsible for transportation management and operations in an environment in which they need to balance the expectations of the public, the priorities of management, demands from a constantly changing technological environment, and the regional need for collaboration with decreasing levels of resources at their disposal. STARNET was expected to promote the sharing of real-time data among agencies for the purpose of enhanced transportation management within Sacramento region, but the complex operating environment has proven challenging. However, agencies have shown a strong desire to participate in coordinated and consistent regional approaches in various forums. The concept of STARNET is appealing to agencies, but the operating environment presents constraints which can be strategically addressed. Those recommendations are provided in the ***Industry Review*** section.

Challenges in Implementing Technical Projects

During the project kickoff meeting held on January 21, 2018, multiple survey questions were provided to participating agencies. Seventy percent of agencies rated their organizations' technological maturity as entry level or mid-level (where many technologies exist, and integration is happening). Only 25% of agencies rated themselves at advanced levels where they are utilizing technology to innovate.

Agencies identified the following items as the biggest challenges to implementing technological projects in their agency, and many of these challenges were reiterated during the STARNET feedback sessions:

Table 6 - Agency Challenges

1. (Technical) knowledge/staff/training
2. Integration (of new technology) with existing technologies
3. Upgrades of existing technologies
4. Operating processes (or lack thereof) and public agency funding restrictions
5. Development of standards and/or implementation plans
6. Multiple databases (for multiple systems)
7. Differing objectives (local versus regional, short term versus long-term)

The effects of these challenges on the adoption and utilization of STARNET were expressed in various ways by SACOG and partner agencies. Those effects are presented in the ***Stakeholder Feedback and Changes in Needs*** section and are summarized below as pain points.

STARNET Pain Points

Some non-technical pain points that were brought up by partner agencies regard adaptation of STARNET, using STARNET in their operations, and providing data to STARNET. These pain points are listed below as absence or lack of the following:

Table 7 - STARNET Technical Pain Points

i.	In-house resources and/or unavailability of funds to hire more resources
ii.	Expertise to provide guidance on operating STARNET and provide the first level of technical and operational support for STARNET
iii.	Training on how to operate and troubleshoot STARNET when skilled resources are available
iv.	MOUs and other agreement between SACOG and agencies. Such MOUs are necessary to align local and regional objectives and secure management commitment for making STARNET an agency's priority
v.	Clarity regarding how STARNET fits within existing systems/business processes in use at the agencies. Even when there is a clear understanding of this relationship, STARNET's inability to ingest data that is already available in the legacy systems or recreating incidents manually in STARNET. The challenge lies in efficiently managing legacy systems and STARNET without duplicating efforts to create the same data in two systems.
vi.	Clear understanding as to what in-house data is useful for other agencies. Cities have multiple data sources and do not know which data to share using STARNET.
vii.	Clear agreements regarding ownership of data and privacy/security concerns as well as the responsibility to address public comments regarding the data.
viii.	Clear policies regarding roles and responsibilities around data ownership, security, and dissemination.
ix.	Understanding on how STARNET is relevant in day-to-day operations of the agencies.
x.	Standard operating procedures for managing transportation operations and emergencies

Although MOUs, such as resolution 2005-246 from the City of Elk Grove, were signed between agencies and SACOG to participate in STARNET to a promote regional approach to transportation, commitments were not received from partner agencies. SACOG stated that these resolutions were executed during 2005–2006; however, STARNET was implemented in 2010–2011. The people behind these commitments either changed roles during this time or were no longer with the agencies, which resulted in waning political and management commitment to STARNET. This lack of commitment from executives and city councils resulted in another major challenge—the lack of resources available to participate in and operate STARNET. Many transportation agencies interviewed during the kickoff process have only one or two staff members dedicated to managing transportation operations. At least one agency was operating at a staff level 50% lower than what it had in 2007–2008. The partner agencies recognize and face the very challenges that STARNET was built to address. Issues such as incident creation/management, traffic congestion, transit ridership, big data processing, lessons learned from other agencies, and traffic management during special events were brought forward as top transportation issues. However, without sufficient resources, agencies have resorted to not using and operating STARNET.

Agency-Specific Needs

Partner agencies from rural areas of SACOG region indicated that traffic management systems should address challenges that are specific to rural areas. Agencies in rural areas of the Sacramento region face unique challenges such as traffic data availability, traveler information, advanced warnings regarding transportation conditions (when possible), infrequent and low demand ~~on~~ of transit, etc. Many of these needs can be addressed directly through STARNET, yet the agencies in rural parts of the Sacramento region have not indicated why they have not been using STARNET.

In this gap analysis, STARNET's current status is assessed against program goals established by SACOG. The causes of the gaps and the pain points have been listed and some of them have been discussed. This gap analysis should address SACOG's need that "if the initial goals for STARNET have [not] been met… then identify and analyze which specific goals were not met." As a result of this gap analysis, we have concluded that though none of the six program goals are *completely* met, some are partially met. Using the pain points derived from user feedback in the ***Stakeholder Feedback and Changes in Needs*** section, we have developed a new mission for STARNET and recommendations to achieve the mission. The new mission and the recommendations are presented in the ***New STARNET: Vision and Recommendations*** section.

NEXT GENERATION STARNET: VISION AND RECOMMENDATIONS

The following section explains the vision and recommendations for the next generation STARNET. STARNET refers to the entire regional data sharing and communication architecture as described below.

New Vision and Objectives for STARNET

An updated vision is proposed for STARNET, based on the user feedback on existing STARNET, unmet user needs, user desires and industry review. The collected feedback was the basis for user needs and desires listed in the ***Stakeholder Feedback and Changes in Needs*** section. Based on the received feedback, below is the proposed mission statement for STARNET:

> STARNET's mission is to improve traffic flow and reduce vehicle emissions in the Sacramento region by coordinating intelligent, real-time transportation data to make travel easier for all users, from commuters to emergency responders.

Connected systems and regional coordination is the new manner in which most concentrated networks are beginning to operate. With a consolidation of the existing infrastructure, STARNET can provide the regional communication infrastructure where field devices are connected to the respective operation center while providing data to the region as well. Such a connected system will allow an increase in efficiency of transportation operations and, better coordinated emergency response by sharing video feeds and control of local camera and field devices. While such coordination for day to day operation can improve efficiency, it also allows SACOG and its partner agencies to engage in long-term regional planning and become the hub of providing data analytics to improve operations region-wide. The overall objectives of the next generation STARNET are listed and explained below:

- Provide regional communication infrastructure
- Increase efficiency of transportation operations and emergency response
- Integrate data from various transportation modes and systems
- Enable sharing of data and videos among partner agencies using sharing standards and protocols
- Enable dynamic control of field devices
- Function as the regional transportation data aggregation and analytics provider

Drivers for New Vision

The driving forces behind the new vision are the shortcomings in the existing implementation and gaps in utilization. These shortcomings manifested themselves in many aspects of the system and across agencies. In proposing the new vision, these pain points, as described in the ***Gap Analysis*** section, were considered along with following factors:

Operating Environment:

STARNET operates in an area where multiple ITS projects and ITS trends are constantly influencing the areas the agency needs to manage, the systems/tools they use to manage these changing needs, the data those systems/tools will generate and the need to share that data with other organizations or with the public. The following is a short list of projects/disruptive technologies that influence expectations from STARNET:

- Connected Vehicle/Autonomous Vehicles (CAV)
- Shared Mobility
- Regional Communications
- Independent and non-collaborative ITS Planning
- Transportation Network Carriers (TNCs) [Uber, Lyft, etc.]

Expansion of current features:

- Collect and disseminate transportation data for the Sacramento region
- Ability to extend data sources and integration with new system
- Provide interfaces to data for partner agencies and public (511)
- Improvement in operations

Causes for existing gaps:

- STARNET may have served the needs of the region at the time of inception, but the mission and the goals have not been updated for more than 10 years.
- STARNET was designed in 2006 and some system components are older than 10 years. This is causing gaps in ability of the system to serve user needs.
- STARNET is a regional system, which requires coordination between various agencies. Not all agencies have the same resources and capabilities as others. For this reason there needs to be a baseline for sharing data that promotes cooperation from all agencies in the SACOG jurisdiction.

New expectations from STARNET:

- To be able to efficiently and effectively address emerging user needs as listed in Appendix L
- To be able to facilitate new business initiatives and future projects with maximum utilization of existing systems.

Findings from the Industry review STARNET can:

- Become a regional turnkey solution to facilitate, collaborate and coordinate
- Benefit from modern infrastructure; hardware, software and communication
- Provide an efficient solution to reduce time, cost and resources for partner agencies
- Address user needs for real-time data
- Generate predictive information based on historical data
- Implement industry best practices and ITS standards wherever possible
- Improve stakeholder engagement

Recommendations

Today's ITS environment requires agencies and cities to coordinate their activities and participate in regional planning as opposed to viewing their own areas for growth. Activities and events occurring in neighboring cities have an impact throughout the region. An incident on the highway can have far-reaching traffic backups and could be a cause of other incidents as well, having a regional impact. Therefore, planning and management of ITS infrastructure should be done on a regional level and with participation of all stakeholders sharing data and information and coordination among partners. STARNET provides a perfect platform for enabling such planning and coordination on a regional level.

In order to meet the new STARNET objectives, a set of recommendations are given below. As the proposed vision of STARNET is more comprehensive than the prior vision, these recommendations will help to bridge the gap of adaptation by partner agencies while increasing utilization of inter-agency data sharing. This document provides the strategic changes or improvements to be made to the program and lists high level activities. A high-level execution plan is provided in the next section listing which activities can be conducted in short, medium and long-term. These recommendations are listed here followed by details for each.

Table 8 - Summary of STARNET Recommendations and Proposed Activities

Recommendation	List of Proposed Activities
#1: Run STARNET as a program with dedicated budget and resources.	1. Establish STARNET Program with clearly defined goals 2. Appoint Program Manager 3. Allocate program budget 4. Prepare and maintain STARNET Operations and Maintenance manual 5. Develop STARNET performance measures 6. Monitor STARNET usage and performance 7. Assign clear roles and responsibilities 8. Develop and train STARNET champions
#2: Create outreach and communication plans	1. Develop outreach plans for partner agencies 2. Develop marketing and communication plans for public 3. Execute outreach and communication plans
#3: Enhance, expand, operate and maintain infrastructure to provide fast and reliable regional communication and information sharing	1. Build and maintain comprehensive infrastructure inventory 2. Document operating and maintenance procedures and develop upgrade plan 3. Build network utilization and usage baseline 4. Upgrade STARNET infrastructure
#4: Assist agencies to integrate and operate STARNET	1. Provide management commitment through agreements 2. Conduct agency level system and data audit 3. Develop detailed training documents 4. Provide technical guidance to agencies 5. Provide resources for staff development
#5: Develop institutional processes for regional transportation operations and emergency response	1. Redefine regional STARNET use cases 2. Develop regional standard operating processes 3. Generate and distribute usable information based on predictive analysis

Recommendation	List of Proposed Activities
#6: Integrate data from various transportation modes and systems	1. Prioritize data types 2. Automate data import 3. Implement ATSPM regionally 4. Collect data from all stakeholder agencies 5. Provide alerts when agency data feed is unavailable 6. Provide alerts when agency equipment is unavailable
#7: Facilitate data, data analytics and video sharing among partner agencies	1. Set up regional transportation planning database 2. Develop data management and governance plan 3. Develop data and data sharing standards 4. Publish new datasets
#8: Enable real-time access and control of field devices	1. Develop STARGATE interfaces for new data type 2. Develop protocols to access field equipment
#9: Develop and distribute data analytics	1. Develop data analytics plan 2. Develop data analytics 3. Provide predictive notifications

These recommendations are described in detail below:

Recommendation #1: Run STARNET as a program with dedicated budget and resources.
A regional network like STARNET has multiple stakeholders, multiple components, multiple interfaces, many types of users and various needs of collecting as well distributing data. In order for STARNET to play that role, these activities should be managed by dedicated resources ensured by multi-year budgets. This will ensure the stakeholders that STARNET infrastructure will always be there for them to use and benefit from. In addition, it will also provide the ability to store and analyze large amounts of data generated. LA Metro, for instance, has a program level funding allocated for multiple years. As a part of this program the program manager can work with multiple agencies looking to purchase same or similar technology and aid as well as promote standardization. As an example, in Los Angeles, if Metro (agency) wanted to purchase Inrix data, RIITS negotiated a license with Inrix so that all RIITS partner agencies can use the data.

This can be achieved by conducting the following activities:

1. **Establish STARNET Program with Clearly Defined Goals**: SACOG should establish STARNET as a program with clear goals. From the goals, projects and project level deliverables shall be developed with clear timelines. Additionally, risks, stakeholders, roles, and responsibilities should be identified and managed as per industry standard program management methodologies. This will establish STARNET as a vital component of the regional transportation strategy.
2. **Appoint Program Manager:** SACOG must appoint a dedicated program manager who will represent SACOG, the sponsor, whose primary responsibility would be to manage and oversee the day to day operations and long-term viability of STARNET. The program manager will be point person for coordinating activities with participating agencies, standardization of operations, establishing standard operating procedures and the escalation point for conflicts or resolving discrepancies.
3. **Allocate program budget:** STARNET program must have a dedicated long-term budget and stable source of funding. This could come from SACOG and once the system is established and stable with those participating reaping benefits from the system, they must also begin to contribute to the funding

on an annual basis. Such contribution from participating agencies will ensure there is buy-in from the stakeholders and will go a long way in establishing STARNET as a true regional program.

4. **Prepare and maintain STARNET Operations and Maintenance manual**: This document will be the blueprint for operations and maintenance for STARNET. This document will include sections such as data collection and dissemination processes, network diagrams including switches, routers, firewalls and other network equipment, maintenance processes like adding new components, startup, shutdown, etc. , information about ISPs and other network arrangements such as point-to-point, etc., STARNET administration, performance requirements, data and data flows, physical architecture of the system, inventory of equipment, etc., CARS/STARNET Application and administration and troubleshooting of the application
5. **Develop STARNET performance measures:** It is recommended that STARNET undertakes a detailed study of multiple systems and develop a performance measurement strategy that is suitable. The performance measurement strategy should provide list of performance measures for each program objective, define baselines, develop systems to collect and analyze performance metrics and create periodic reports based on metrics. Performance of STARNET can be measured quantitatively as well as qualitatively using a number of parameters such as field devices for quantitative measurements and overall improvement of incident response time for qualitative measurements. Such Key Performance Indicators (KPI's) must be developed after a full inventory and analysis of the system has been conducted as stated in the recommendations. Sample performance reports are provided in **Appendix G.**
6. **Monitor STARNET usage and performance**: Partner agencies and SACOG should review the usage of STARNET and discuss challenges in operating STARNET during regular ITS Working Group meetings. It is recommended to have monthly meetings of the ITS Partnership with STARNET usage review as one of agenda item.
7. **Assign clear roles and responsibilities**: As part of the agreements and MOUs, develop a matrix (RACI Matrix) indicating following roles; Responsible, Assigned, Consulted, and Informed. This matrix will help SAGOG to understand resource commitment from the agencies and will provide clarity to the agency operators as well as their management about their responsibilities. It is also recommended to get commitment from agency management.
8. **Develop and train STARNET champions**: Establish a STARNET champion in each agency who will internally drive need and importance of data sharing using STARNET. This person can also be trained to respond to any STARNET related issues.

Recommendation #2: Create outreach and communication plans.

STARNET benefits must be effectively communicated with the partner agencies, stakeholders as well as the traveling public. STARNET stakeholders should know how it is useful to them, how they can make use of STARNET in making effective decisions, and how they can contribute to STARNET. It is recommended to develop robust outreach plans for agency partners and marketing and promotion plans for the public to enhance usage of public interfaces. If other outreach and communication plans exist within SACOG, STARNET program could leverage those as and when possible.

This can be achieved by conducting the following activities:

1. **Develop outreach plans for partner agencies**: Trust within partner agencies is a must for the success of STARNET. SACOG should consider partner agencies as internal customers and develop an outreach plan which must include multiple options for high level meetings and working group level meetings to coordinate efforts and day to day operations. It is recommended to hire a marketing and outreach consultant to develop these plans.

2. **Develop marketing and communication plans for public**: For public users of STARNET, such as 511, XML data users, radio/TV stations, etc., a robust communication and marketing strategy should be developed. It is recommended to hire a marketing and outreach consultant to develop these plans.
3. **Execute outreach and communication plans**: SACOG Program manager should plan and conduct frequent outreach activities with agencies and public as recommended in the outreach and communication plans. Until such plans are developed, it is recommended to contact each agency at least once a month. Meetings such as ITS Partnership forums are surely advisable, but they are not adequate, on their own, to promote trust and working relationships between SACOG and the partner agencies. Additional meetings or dedicated periodic calls should be scheduled in order to formalize the continuous and meaningful communication.

Recommendation #3: Enhance, expand, operate and maintain infrastructure to provide fast and reliable regional communication and information sharing.

In order for all participating agencies to contribute and benefit from regional planning the overall state of the infrastructure must be optimum. Infrastructure could mean access to fiber optics, routers and communication equipment and access to the regional software platform so that they not only provide data but can also access information for their own use. Infrastructure should be provided to partner agencies so that multiple network enhancement projects can be grouped together resulting in cost savings as well as building a regionally capable network.

In order to provide a highly available data and information sharing platform for the region, STARNET's communication and network infrastructure should be properly identified, operated and maintained for optimal utilization and continuously upgraded to meet evolving needs of the region. In order to begin to utilize the system on a regional basis a comprehensive analysis of the built infrastructure is required. This is essential as a number of existing network architecture and designs either don't exist or are difficult to find. Additionally, STARNET can provide regional infrastructure that can be utilized by agencies to prepare for the wave of new technologies such as CAV and other innovations in transportation. In addition, this will also provide the ability to store and analyze large amounts of data generated. For instance, in response to analysis of long-term data from road conditions, traffic patterns, speed data and other factors that are collected by the system, city and highway planners and engineers could move or place changeable message signs to improve traffic flows and reduce congestion.

This can be achieved by conducting the following activities:

1. **Build and maintain comprehensive infrastructure inventory**: Take complete inventory of communication infrastructure such as fiber optics and network equipment such as firewalls, routers, switches, etc.,
2. **Document operating and maintenance procedures and develop upgrade plan**: for the communication and network infrastructure: This is essential as a number of existing network architecture and design drawings either don't exist or are difficult to find. An expert consultant should be engaged to take complete inventory of communication infrastructure such as fiber optics, network equipment such as firewalls, routers, switches, etc., network architecture, operation and maintenance processes, and roadmap for upgrading the infrastructure.
3. **Build network utilization and usage baseline**: An investigation is needed to determine how the existing network infrastructure is currently used. As a result of the investigation, complete Network 'as-built' and operations documentations need to be prepared which must also include recommendations on upgrading and updating the network infrastructure.

4. **Upgrade STARNET infrastructure**: Based on the infrastructure upgrade plan, undertake projects to upgrade STARNET infrastructure.

Recommendation #4: Assist agencies to integrate and operate STARNET.

Many agencies have provided feedback that they face multiple internal challenges to integrate and operate STARNET. Removing the internal barriers is a must for success of STARNET. This can be achieved by conducting the following activities:

1. **Provide management commitment through agreements:** SACOG and partner agencies should formalize their collaboration using MOUs and agreements. It is recommended to use specific agreements for specific purpose. The MOUs and agreements will establish the formal need for communication which then will have to be fortified using the outreach plan and consistent follow ups. Based on industry review, the following types of agreements are used: Master Agreements (agreement describing roles and responsibilities in case regional traffic coordination is required) , Operational Agreements (agreement describing the roles and responsibilities when an incident occurs), Inter-agency Agreements (agreement describing an agency controlling another agency's traffic signals), and MOUs and Funding Agreements (agreement describing the funding sources and budget to maintain the ATIS infrastructure).
2. **Conduct agency level system and data audit**: Similar to the infrastructure audit mentioned above, conduct detailed audit for systems used by partner agencies to manage and respond to transportation operations, including inventory systems, data collected by each system, how frequently the systems are used, what tasks are performed by each system, resources (time, efforts) needed to operate and maintain each system, challenges faced by agency to operate and maintain each system, etc. A detailed list of questions should be developed. Meetings with agencies' operations and IT staff should be conducted to find out various constraints and bottlenecks at the agency level. This data can be used to create detailed regional inventory of systems, data, resource needs, etc. This data then should be used to analyze the obstacles in integrating and operating STARNET.
3. **Develop detailed training documents**: The frequent reviews of the STARNET goals and operating procedures must also include review of the training. It should be a standard process that while training on the system and operating procedures is important, it is not a one-time event. Training must be an ongoing task where each agency conducts internal training but there also needs to be a regional training and workshops. SACOG should extensively update existing documentation such as "CARS CAD Training Document" and "CARS-5 training" documents. Additionally, videos of standard operating tasks and troubleshooting should be created for easy and quick reference.
4. **Provide technical guidance to agencies:** STARNET program, through resident experts or through consultants, should provide technical support to agencies to select new technologies, integrate data from technologies with STARNET, and to provide them a roadmap to enhance their technology as well as infrastructure so that it can easily fit in the STARNET ecosystem.
5. **Provide resources for staff development**: As part of the STARNET program, SACOG should provide agencies recommendations on what skills to look for in new staff so that they can operate and maintain STARNET installation at the agency. Also, SACOG should provide recommendations on training for existing staff for STARNET as well as for efficient use of existing technology and ability to co-ordinate and collaborate with other providers to resolve regional operational and emergency scenarios.

Recommendation #5: Develop institutional processes for regional transportation operations and emergency response.

Many agencies have asked for more formal processes and procedures in order to facilitate inter agency communication to efficiently and collaboratively respond to a regional operational scenario or emergency. It is recommended that SACOG develop various regional agreements and operational processes and provide

regional standards. The STARNET platform can provide wide ranging benefits to the entire region with the collection of data and display and analysis of the data to provide information. This can be achieved by conducting the following activities:

1. **Redefine Regional STARNET Use cases:** Update existing use cases and add new use cases. Roadside, signal, ramp, transit and other forms of data collected can be used for multiple cases. The uses of data and the information generated from the analysis of data can be applied to different regions based on their unique circumstances. Determine additional manners of data analysis which could include signal data analysis, biking data analysis, traffic speed analysis, spill over due to major traffic incidents, etc.
2. **Develop Regional Standard Operating Processes:** Develop common standard and operating procedures that can be implemented throughout the stakeholders and participating agencies. Develop and implement standard operating procedures of data collection, storing, sharing and analysis. These standard processes must be implemented across all stakeholder agencies and participating partners to ensure consistency.
3. **Generate and distribute usable information based on predictive analysis**: Collection and analysis of data on a long-term basis provides an efficient use of the collective planning process. The analysis of these data over long periods of time will allow SACOG and the participating agencies to develop predictive tools and help in better planning for events and coordination of emergency response.

Recommendation #6: Integrate data from various transportation modes and systems.

In addition to current data collection processes, STARNET should improve quantity and types of data. This can be achieved by conducting the following activities:

1. **Prioritize data types:** Define list of priority data sets. Instead of working with every agency on multiple types of data, focus on incorporating prioritized data sets first. These data sets can be prioritized based on their impact on enhancing regional transportation management.
2. **Utilize off the shelf ATSPM systems** across the region to share performance measure data for traffic signal systems.
3. **Automate data import**: Update existing data import modules to import priority data sets for all agencies. Develop new data import modules for priority data sets. Standard operating procedures should include implementation of procedures where consistent data can be automatically imported. Provide technical assistance to agencies during that process.
4. **Implement ATSPM regionally:** Implement Automated Traffic Signal Performance Measures (ATSPM) through the region to assess performance of traffic signals. ATSPM promotes maintenance and operations improvements, while maximizing system efficiency through performance measures.
5. **Collect prioritized data from all agencies:** Outreach to all agencies, import priority data sets and include them in STARNET.
6. **Provide alerts when agency data is unavailable**: Update STARNET to provide alerts to concerned parties when data feed or camera feed is unavailable.
7. **Provide alerts when agency equipment is unavailable:** Update STARNET to provide alerts to concerned parties when roadside equipment is unavailable. As STARNET is connected to the roadside equipment such as CCTV cameras, STARNET can provide notification to owner agencies when their equipment is unavailable.

Recommendation #7: Facilitate data, data analytics and video sharing among partner agencies.

STARNET stakeholders have expressed lack of clarity about which datasets they can share, lack of resources to create or share the data and concerns about data ownership, data privacy and data security once it is

shared with STARNET. These issues, along with technical difficulties in data import, should be resolved to facilitate data sharing. This can be achieved by conducting the following activities:

1. **Set up regional planning database:** As planned, SACOG should establish a Transportation Planning Database to hold regional data. This database should be designed and developed to address current and future data needs. A database design and development activity should be undertaken to facilitate this process. Once established, all STARNET data collection modules should store data in this database and all data dissemination should happen from it as well. This database will provide raw data to generate historical trends and to run predictive analysis.
2. **Develop data management and governance plan:** SACOG should develop a comprehensive data management and governance plan to alleviate concerns and confusions of stakeholders. Data privacy and data security should be addressed using standard security policies at software and hardware level.
3. **Develop data and data sharing standards**: SACOG to act as promoter of data standards for the region so that current and future data sets can be easily shared among agencies. Educate and train agencies on data standards, such as Traffic Management Data Dictionary (TMDD), and encourage them to choose technologies which comply with those standards, including those for communication, ITS, and C2C communications. A sample list of multiple data standards used in Los Angeles RIITS is presented in **Appendix F**.
4. **Publish new datasets**: STARNET shall provide additional information requested by stakeholders. This includes event information, locations for bike sharing, car sharing, EV Charging stations and parking. This information can be used for enhanced operations and emergency or event planning and should be integrated in the use case scenario definitions. A comprehensive list of priority data elements is provided in the ***New STARNET: Vision and Recommendations*** section.

Recommendation #8: Enable real-time access and control of field devices.

STARNET stakeholders have expressed a need to access and control ramp meters, CCTV cameras and traffic signals using STARNET interface. Use of this equipment is critical in containing impacts of a transportation incident or emergency. Based on experiments on ramp metering in the Florida SunGuide system, Ramp signaling has been proven as a low-cost congestion management system allowing TMCs to control the number of vehicles entering the freeway in order to optimize flow and reduce congestion. This can be achieved by conducting the following activities:

1. **Develop STARGATE interfaces for new data types:** SACOG should undertake development of STARGATE modules to access and control ramp meters, CCTV cameras and Traffic Signals. Once the data import process works, update data dissemination interfaces to provide data to consumers.
2. **Develop protocols to access field equipment:** Undertake study to gather various use cases for accessing field equipment. Once these use cases are developed, create a regional protocol to access this equipment. Many times, one agency may need to access a CCTV camera or traffic signal owned by another agency or a regional TMC may need access to all equipment by all agencies.

Recommendation #9: Develop and distribute data analytics.

Analysis conducted on the data collected by STARNET can be put to use for long-term planning not only for SACOG, but also for other partner agencies. Smaller rural agencies may not have the resources to conduct their own research but can be greatly benefitted from the analysis conducted on the collected data. Collection and analysis of data must provide actionable information that can be used immediately for partner agencies. For instance, real time comparison of real time data with historical data can provide valuable information to traffic operations centers where unusual traffic patterns and speed data are compared.

This can be achieved by conducting the following activities:

1. **Develop data analytics plan:** Undertake development of a data analytics plan to detail needs for data analytics, reporting and predictive information needed for STARNET as well as SACOG's planning needs.
2. **Implement data analytics**: Implement data analytics tools and integrate with other systems, such as CARS, in order to make the analytics available to all agencies.
3. **Provide predictive notifications**: Develop and implement an alert strategy. Provide alerts to agencies when events with potential to cause large impacts happen.

Program Data Elements

Priority data types to be included in the new STARNET program are listed in the table below with descriptions. The purpose of this table is to indicate which new data elements should be included in STARNET and what should be the priority of that element. When necessary, the purpose of the new data element is also mentioned.

STARNET shall collect, store and disseminate the following key data elements. Industry review has indicated that current datasets collected by STARNET are as per industry best practices and STARNET should continue to collect those datasets in order to meet its goals of improving operations efficiency.

Table 9 lists proposed data elements STARNET should collect or strive to collect in order to meet its mission of improving effectiveness and efficiency of transportation operations as well as emergency response. This list includes data currently collected by STARNET as well as new datasets. A priority is allocated to each dataset based on the importance of the dataset for STARNET goals.

Execution Plan

The following execution plan shown in **Table 10** is proposed to carry out the recommendations provided above. The activities mentioned under each recommendation are aligned logically with short-term tasks being the first, medium-term being second and long-term tasks being last.

Table 9 - STARNET Data Types

Data Type	Priority	Description and Purpose
Highway Data		
Traffic Speeds (HOV/Non-HOV)	**High**	Current traffic speed by direction.
Incidents on Highways	**High**	Incident data coming from Caltrans, WAZE, and other sources.
Vehicle Count, Occupancy and Speed	**High**	Data from vehicle counting stations installed along the freeway. This data may be used for additional analysis and planning.
CMS Data	**High**	Changeable Message Signs data provide by Caltrans and cities.
Highway Advisories	**Low**	Other highway advisories such as Amber alerts, stolen vehicle, etc.
Wind Speed/Directions, Precipitation, Pavement Temperature	**Low**	Weather data to supplement any traffic alerts such as “Chains required”, flooded roads, etc.
Lane Closure Status	**High**	Data provided by Caltrans and Emergency Responders
Video	**High**	Feeds from CCTV cameras
Ramp Meters	**High**	Status of ramp meters; on/off, timing mode, signal status
Tolls	**Medium**	Tolls, HOV tolls/times, express lane charges, etc. This data can be used in traveler information system.
Arterial Data		
Traffic Speed	**High**	Speeds on arterials
Traffic Signals	**High**	Current color, current timing mode, traffic volume at intersections (if available)
Incidents/Lane Closure/Construction	**High**	CAD from local PD, road closures, constructions
Video	**Medium**	CCTV feeds from cameras installed at intersections or at other locations along the street
Transit Data		
Transit Real Time	**High**	Vehicle Locations, real time departures and real time alerts
Transit Static	**High**	Routes, trips, fares, transfers, passes, alerts, re-routing, transit parking
Parking		
Static Parking	**Medium**	Garage location, capacity, price, operating times, etc.
Real Time Parking	**Medium**	Availability of street parking spots as well as in garages. Availability for each type; accessible, regular, Electrical Vehicles (EV), Carpool vehicles, etc. Current pricing.
Bicycling		
Bicycle Paths	**Low**	Designated bicycle paths and bike lane data to be used in bike trip planning.
Bike Sharing Locations	**Low**	Locations of bike sharing locations (e.g. Ford GoBike), availability of regular/hybrid bikes
Other		
EV Charging Station	**Medium**	Electric Vehicle charging station locations, number of spots and type of charging available
Third Party Data (Inrix, Google, etc.)	**High**	Get regional data from third party providers such as Inrix, HERE, Google, etc. to complement or supplement data collected by Caltrans and partner agencies.

Table 10 - Recommendation Execution Timeline

Short Term Tasks	Medium Term Tasks	Long-term Tasks
1. Establish STARNET program, program goals 2. Appoint Program Manager 3. Assign clear responsibilities 4. Allocate budget 5. Prepare and maintain STARNET Operations and Maintenance manual 6. Develop outreach plans for partner agencies 7. Develop marketing and communication plans for public 8. Build and maintain comprehensive infrastructure inventory 9. Document operating and maintenance procedures and develop upgrade plan 10. Conduct agency level system and data audit 11. Develop detailed training documents 12. Develop Regional Standard Operating Processes 13. Redefine Regional STARNET Use cases 14. Prioritize data types 15. Develop Data Management and Governance Plan 16. Develop data and data Sharing Standards	1. Prepare and maintain STARNET Operations and Maintenance manual 2. Develop STARNET performance measures 3. Monitor STARNET usage performance 4. Assign clear roles and responsibilities 5. Develop and train STARNET champions 6. Execute outreach and communication plans 7. Develop network utilization and usage baseline 8. Provide management commitment through agreements 9. Automate Data Import 10. Setup Regional Transportation Planning Database 11. Develop STARGATE interfaces for new data type 12. Develop protocols to access field equipment 13. Develop Data Analytics plan	1. Conduct frequent reviews 2. Upgrade STARNET infrastructure 3. Provide technical guidance to agencies 4. Provide resources for staff development 5. Generate and distribute usable information based on predictive analysis 6. Collect data from all stakeholder agencies 7. Develop data analytics 8. Provide alerts when agency equipment is unavailable 9. Provide alerts when agency data feed is unavailable. 10. Implement ATSPM regionally 11. Publish new datasets

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13. Ford GoBike: https://member.fordgobike.com/map/
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APPENDIX A – QUESTIONS FOR MEETINGS

Meeting with Castle Rock (STARNET integrator)

1. Current System Architecture Diagram of STARNET? Design documents? System configuration? Cloud based?
2. STARNET users
    1. Contributors to STARNET (Who, What, how, when, how frequently)
    2. Consumers of STARNET data (Who, What, how, when, how frequently)
    3. How many stakeholders are using STARNET? How many active users are there and what are usage stats? What user statistics get collected? Are there monthly/quarterly/annual reports?
3. Where is STARNET used (TOC, agency offices, etc.)
4. Data types collected/distributed by STARNET? How frequently? What are policies for data/information storage and security? Who is responsible database administration? Where is data stored (locally/cloud)?
5. Is any analysis done on the data collected by STARNET, if yes by whom?
6. What is the process to add new agency / new data stream to STARNET?
7. STARNET operation and maintenance: Who, resources, what kind of support is provided to users?
8. Roles and responsibilities of SACOG, CR, Stakeholders, Users (Consumers and Contributors)
9. Are there KPIs defined for STARNET, how are they measured, are they met?
10. How do you collect feedback/improvement suggestions from users? Can we see feedback received so far?
11. Is STARNET built to satisfy all requirements as defined in the requirements document? (As available at: https://www.fhwa.dot.gov/cadiv/segb/files/starnet/starnetreq.doc)? Can it be confirmed if all requirement stated in the requirements document is satisfied by current STARNET?
12. Can you provide further details about STARNET system (HW/SW)?
    1. Interfaces (public/private)
    2. Servers
    3. Database(s)
    4. Interfaces, application program interfaces (API), etc. for data collection
    5. Network (SACOG fiber or third-party ISPs)
    6. Level of resources needed to maintain STARNET
    7. Current utilization of infrastructure: Database storage, bandwidth, system load, etc.
    8. Is STARNET equipment/cost of maintenance shared with other stakeholders/CR Customers? Is it an advisable model going forward?
    9. How easily/quickly can the system be scaled? What is current AWS usage of SACOG specific usage?
13. How is CARS used in other places it is deployed, what data is being shared, how SACOG usage can be compared with other customers?
14. Is GTFS real time feed or other data feeds integrated from transit agencies? If yes, which?
15. Any known limitations of the system in fulfilling current requirement.
16. Are there any verification plans, stakeholder co-op plan, data management plan, etc. that were created during project implementation?
17. Can you provide Timeline of STARNET implementation?
18. Are there any detailed training document on STARNET interface? What type and level of training were provided to Stakeholders?
19. Feedback received by agency on STARNET and is there a compilation of these feedbacks?
20. What is connection between CARS and STARNET?
21. Other places where STARNET interfaces are implemented by CR?

Concept of Operations Meeting

How is STARNET used today and what do you like about it?

- What data/contents are available on STARNET today?
- Have you used STARNET to manage a transportation emergency?
- What do you like about the mission of STARNET?
- What do you like about data/contents available on STARNET today?

What are the "pain-points" of STARNET?

- What components of STARNET are/were difficult to use?
- What additional data could make STARNET more useful?
- In absence of STARNET, how is critical data exchanged during emergencies?

Managing Incidents and Emergencies

- How do you envision the role of STARNET in managing response, communication, stakeholder participation, control, etc.?
  - Traffic incidents and emergencies [major spill and multiple accidents on highway section affecting many cities during mid-week morning peak]
  - Transit incidents and emergencies [major light rail disruptions due to mechanical failure/accident affecting commuters from many cities during mid-week morning peak]
  - Natural Disasters [flooding due to storms or other natural disasters resulting in closing major sections of freeways and affecting multiple transit routes from different agencies]
  - CV and AV [how do you envision inclusion of shared mobility, connected/autonomous vehicles, etc. in STARNET]
  - Data exchange [types of data collected and exchanged]

Meeting with three major STARNET stakeholders on June 23, 2018

1. **Original purpose behind building STARNET**
   a. Changes in use cases of STARNET since inception.
   b. Changes in needs or expectations of stakeholder resulting in limited usage.
2. **STARNET Infrastructure**
   a. Understand extent of STARNET infrastructure as it exists today compared to what is provided in original documents (concept of operations, etc.).
   b. Discuss fiber optics, networking equipment. Plans for upgrading infrastructure in near future.
3. **Usage of STARNET**
   a. Understand who is using STARNET today and how it gets used. How TMC, TOCs, and EOCs use it.
   b. Discuss existing SW/APIs used to exchange information.
   c. Discuss speed, security, sharing policies, etc.
4. **STARNET Data**
   a. Understand existing data types collected using STARNET infrastructure, who manages the data, how is data stored and governed.
5. **Stakeholder Roles and Responsibilities**
   a. How they are today and what were they expected to be. What has led to changes in roles and responsibilities.

Discuss stakeholders responsible for managing STARNET infrastructure.

APPENDIX B – FEEDBACK RECEIVED

Feedback from SACOG's System Integrator

Since 2011, Castle Rock and SACOG has conducted multiple training sessions and the initial enthusiasm for the program has not resulted in continued wide spread use and data share. This is also highlighted by SACOG receiving very few requests from agencies to make their datasets available to other agencies using STARNET. In order to mitigate this lack of usage, specific agencies should commit a person as a STARNET champion. Castle Rock can then train the user further so that this person can support other users within the agency and can act as first level of support. However, creating a STARNET champion or super user may not be the ultimate answer. For example, City of Roseville and/or City of Rancho Cordova, which upon receiving advanced trainings, started sharing the data for some time but after few days the data sharing stopped.

According to Castle Rock, users face challenges at various levels:

1. Agency's commitment to share data (in general with other agencies and in particular with SACOG)
2. Lack of resources to focus on learning new tools, and operating it continuously
3. Lack of training to operate and troubleshoot operation issues
4. Movement of trained and committed people within agency
5. Prior commitment to using other systems
6. Management commitment to share data for regional planning and transportation management

Additionally, it has also been observed that the agencies prefer calling each other during an incident in order to get the data they need rather than depending on a system like STARNET.

Participation of stakeholder and member agencies in the Sacramento region is limited and there does not seem to be any requirement on the stakeholders to participate and use the system. Castle Rock has had most success in integrating CAD data. The most accessible CAD data is from CHP and Caltrans as these agencies have been sharing data with public for long time and are aware of the technical needs as well as have refined organizational directive and procedures to facilitate data sharing.

There has been an overall reluctance on the part of the participating agencies on sharing data as there seems to be a perception that the agencies themselves will need to convert their raw data into the TMDD/IEE 1512 format required for STARNET. Castle Rock and SACOG have made multiple outreach efforts to the agencies to emphasize that the conversion of data will be done with Castle Rock's proprietary algorithm to no avail. One of the primary reasons' agencies may not be participating in sharing data with STARNET is the lack of dedicated resources.

Table 11 - Feedback Received during Kick-Off from Multiple Agencies

Agency/ Meeting Date	New/Unmet needs from STARNET	Future Vision	Other notes
Kick off meeting with KHA/Caltrans (03/12/2018)	• Need more training for O&M of IT systems. Need people who can bridge gap between engineering and electricians • Need Caltrans fleet management for FSP including locator service. • More shared fiber between cities and Caltrans • Get speed data for arterials in a way other than PeMS. • Requested STARNET improvements so that Caltrans can share more data with the local agencies.	• Expects signals to be connected. • Need real time bus information • New Weight in Motion (WIM) technologies.	• As operations are 24x7, there is a desire to support other cities. • Is thinking about emerging technologies in the areas of ICM-Virtual CMS, V2I, ramp metering, CAV, • Would like to start using third party data (DaaS)
City of Citrus Heights (03/14/2018)	• City has many non-working CCTV cameras. Need notifications when cameras go offline. • Communication to the traffic signals is very unstable. Need dedicated fiber. • Limited traffic engineering staff, hence less resources available • More reliable connections to the signals so that they can be managed in real time as needed. • Would like to receive staffing and skill recommendations based on city needs • TOC needs and upgrades • Publish information @Lane closure, Construction related closure, Incidents, Travel Times, PD Requests for messages. • Need to improve inter agency co-ordination • Need to share CCTV camera feeds with other agencies •	• Need video detection system for signalized intersections. • Hosting of servers by individual agencies. • TOC is location constrained. Space is an issue, • City expects to understand the equipment replacement need as soon as possible. • Need bike detection at all new signaled intersections. • Need ITS improvement plan • Need assessment for existing CMS and recommendations for future CMS locations. • Enhancements for arterial/intersection performance metrics •	• City does not have an O&M procedures document • Need locations for EV charging stations.
City of Rancho Cordova	• Needs to install more CCTV • Need to collect travel time data collection • Disseminate information to public thru CMS • Expansion of bicycle and pedestrian detection • Create TMS at future Corp Yard • Address staffing needs due to addition of new technology	• City is going to switch from loop detectors to video detection and radar. • City would like to solve their traffic congestion concerns at Sunrise Blvd, Folsom Blvd./RT Preemption • City wants communication integration with bordering agencies • City desires a vision for regional integration including policies, technologies and politics • City is open for pilot project for autonomous vehicles	

Agency/ Meeting Date	New/Unmet needs from STARNET	Future Vision	Other notes
		• Exploring TDM project to use Lyft to get to transit	
County of Sacramento (March 07, 2018)	• Need more technicians with networking, systems knowledge • Will need staffing recommendations • Will need training on how to utilize current systems more efficiently and effectively as funding for staffing decreases • Need to co-ordinate with SAC RT and South County Transit	• City would like start monitoring 250+ signals which are unmonitored now • County would like to control the CMS signs • County would like communication with every traffic signal • The group thinks there should be a commission/JPA to operate the entire region. Need ability to access and control other agencies during certain times. County has a desire to share their resources as well. • Consider light rail to airport	• County has a staff of 6, down from 12 in 2008 • County does not employ a full time TOC operator • Signal TOC is shared with Transit group • No currently documented O&M procedures • Currently employ a reactive replacement schedule
El Dorado County (March 12, 2018)	• Would like to redirect traffic to back and other quicker routes to reduce congestion. • Has counters and would like to use data form counters at roadside as well as at intersections. • Currently only one tech for fifty traffic signals • Establish connections to existing systems • Utilize Hwy 50 fiber backbone • Integration of Caltrans and County intersections along key corridors • Need one more signal tech in the future • Need recommendations for appropriate staffing levels to meet goals • Seasonal/special event management • Improve co-ordination with Caltrans/Folsom • Need real time traffic data	• County would like to place stationary CMS at few key locations. • County is investigating Google/WAZE for traffic data • Limited cell coverage in the area makes the apps less useful • As existing loops are not working well, county would like to switch from loops to cameras for detection. Considering combined camera/radar for detection. • Would like to have CCTV at major intersections • County desires upgrades to accessible pedestrian signals at intersections • A new CMS on Hwy 50 • Possibility of on demand transit	• County has one CCTV camera • Caltrans has Bluetooth detection along Hwy 50 • Currently there is no operations and maintenance procedures document • ED Transit is very popular and P&R lots are at or above capacity
Concept of Operations Meeting (05/31/2018) – STARNET SESSION	Stakeholders have expressed following needs in the meeting: • Rancho Cordova: Cross-jurisdictional incident data for active traffic management and notifications; rail locations that affect other delays • Sacramento County: Construction data to publish detours and duration information. • Air District: Union Pacific data insights could contribute to improved regional integration of transportation network operations and efficiency.	• Rancho Cordova: Focus on advanced detection; video surveillance; advance signal systems; more automation. Autonomous cars will be in field by 2025. • City of Sacramento: Old cabinets online; ready for future knowing communications is the key	• Is the data transfer happening in any other way outside of STARNET? - Rancho Cordova and County are sharing information with server connections

Agency/ Meeting Date	New/Unmet needs from STARNET	Future Vision	Other notes
	o Bike share locations should be more easily discovered to encourage usage. ● SACOG: There is a need to have some guidance on specific types of data. Need to improve flexibility and ability to share data across boundaries. ● Operators are tasked with inputting data manually, which is not efficient. ● It is crucial to have interfaces between City (systems) and STARNET to cut down (need of more) resources ● Ability to share and view real-time information will be useful ● Need and want to share video ● It is difficult to understand what data is useful to others.	● Caltrans D3: Once ICM is implemented, STARNET could be the backbone for communications.	
Concept of Operations Meeting – Operations Scenario Session	User needs, relevant to STARNET, are summarized from some of the comments made by agencies in earlier session: ● Planned events coordination is satisfactory but ad hoc or unplanned event notifications could improve. ● Transit agencies need more frequent and reliable information about road closures so that they can reroute their transit vehicles. ● Currently there is no process for active response planning. ● California Highway Patrol (CHP) and local Police Departments are not sharing the same Computer Aided Dispatch (CAD). ● There is minimal arterial detection available (loops and video) to monitor arterial conditions ● Third party data is primarily viewed for planning purposes, not real-time traffic monitoring. ● Caltrans uses NPRDMS – INRIX data. ● Dashboards to summarize performance measures at City TMCs for real-time performance will be useful. ● Automated information exchange could be used by transit agencies to convey generic delay messages to both adjacent travelers and waiting transit users. ● Realtime parking information is a vital piece of information to share with the users. ● Transit options should be advertised and encouraged. ● Uber/Lyft options continue to be a viable component of event traffic and traffic management strategies.	● Location information about charging stations for electric and hydrogen fuel vehicles ● Adaptive systems might have more benefit than flush plans. ● Better coordination with public safety agencies could improve response and closure times. ● Existing maintenance responsibilities is mostly reactive. ● It would be beneficial if all local PD CADs were integrated with regional 511. ● Notification from PD to Cities is a problem because communication network is not viable across jurisdictions. ● Push notifications to adjacent agencies would be beneficial. ● Many agencies feel that there is no clear guidance on performance measures. ● Emergency Operations Center (EOC) takes time to be activated. ● Situations develop very quickly, and agencies need to respond quickly. ●	

Agency/ Meeting Date	New/Unmet needs from STARNET	Future Vision	Other notes
	• Event Information can be displayed on Maps for out of area travelers. • Data Needs -Real-time and Historic to reduce recurring-traffic congestion: ▪ Vehicle occupancy data ▪ Photo enforcement ▪ Corridor speeds ▪ Ramp metering congestion ▪ Bicycle detection ▪ Pedestrian detection ▪ Mobile-eye, pedestrian blind spot detection ▪ Travel time data ▪ Bicycle/Ped counts for planning purposes • Data Needs -Real-time and Historic for efficient response to emergency: ▪ Evacuation Routes ▪ QuickMaps ▪ Information on ready.gov ▪ Google/Waze maps		

Feedback received from SACOG

Challenges faced by SACOG during the process:

1. SACOG does not know who is responsible for providing data to STARNET
2. When SACOG finds and contact those people eventually, those people do not respond or do not respond in timely manner
3. When additional help is provided by SACOG/Consultant (Castle Rock), the agencies do not follow through on their tasks, such as testing, etc.

SACOG's Experience/Observations:

- During initial con-ops SACOG contacted many agencies.
- Training has been provided to many agencies.
- Each agency has unique way they handle situation and many agencies are not clear on how to fit STARNET in their operations
- Additionally, agencies are under staffed and cannot allocate resources to operate and provide data on STARNET
- SACOG has been extending various types of assistance to the stakeholders to help them adapt STARNET, however SACOG has not seen enthusiastic response or adaptation of STARNET from stakeholder
- It is felt that the agencies are overlooking the long-term usage of data sharing with other agencies as well as SACOG. Agencies need to be understand their responsibility in that regard and start sharing data.
- SACOG expressed need to engage management of stakeholder agencies so that data sharing at regional level is given a priority
- SACOG has hired full time staff to help agencies with STARNET as well as hired contractors to provide technological help to agencies in integrating their data with STARNET. SACOG maintain record of their assistance provided to agencies.
- SACOG is open to take STARNET in direction participating agencies would like to take, including
    - If agencies are committed to use STARNET keep funding it as is
    - If STARNET is expected to serve new needs, consider them and keep STARNET available with additional features as necessary
    - Stop supporting STARNET altogether
- SACOG provided additional pointers:
    - They do not think that the tool has any major problems, or it is difficult to use
    - Agencies have mentioned that they would like to use STARNET, but they are not using it at all
    - SACOG does not have authority to ask agencies what they should do, SACOG needs co-operation from agencies
    - SACOG thinks that sharing transportation data regionally should be priority for the management of those agencies
- Many times, agencies do not know or are not willing to share data, it is an internal decision that has to be taken.

APPENDIX C – STARNET SYSTEM REQUIREMENT GAPS

Computer Systems to Serve as a Data Source or Sink

Following systems were expected to be implemented in the first implementation of STARNET. Out of 26 systems which were expected to be implemented in STARNET, only 9 are implemented. *This data has to be further verified by SACOG or Castle Rock.*

Table 12 - Computer Systems and Status

Host System	Status	Data	Host System Interface	Implemented in STARNET?
California Highway Patrol, Computer Aided Dispatch system (http://cad.chp.ca.gov)	Existing	Source for roadway incident data.	XML via FTP with RSS notification of changes.	Y
Sacramento Regional Fire/EMS Communications Center, Computer Aided Dispatch system (Northrop Grumman COBOL CAD).	Existing	Source for incident data.	Database read.	N
Yolo County Communications Emergency Service Agency, Computer Aided Dispatch system (Northrop Grumman Altaris CAD)	Existing, but may change	Source for incident data.	Database read.	N
City of Sacramento Police Computer Aided Dispatch System	Existing	Source for incident data.	XML.	Y
County of Sacramento Lane Closure System	Existing	Source for planned and unplanned lane closure data (treated as incidents).	HTML files available on Internet via HTTP.	Y
Caltrans Lane Closure System	Existing	Source for planned lane closure data (treated as incidents).	ASCII file freely available on the Internet via HTTP (http://www.dot.ca.gov/travel/dist_03/lcs/lane_closures_d3_xy.txt)	Y
Caltrans District 3, Advanced Traffic Management System (ATMS)	Existing	Source for static data defining ramp meters, and CMS on freeways, & changeable message sign data.	ASCII files freely available on the Internet via HTTP (e.g., http://www.dot.ca.gov/travel/dist_03/webinit.txt)	Y
Caltrans, Performance Measurement System (PeMS - http://pems.eecs.berkeley.edu)	Existing	Source for static data defining detector stations on freeways.	XML file freely available on the Internet via HTTP.	Y
Caltrans, Performance Measurement System (PeMS - http://pems.eecs.berkeley.edu)	Existing	Source for five-minute processed loop detector data (volume, occupancy, speed) for freeways.	Comma delimited ASCII file freely available on the Internet via FTP.	Y
Caltrans District 3, Front End Protocol Translator (FEPT).	Existing	Source for freeway ramp meter data.	RPC-based.	N
Sacramento Regional Transit District, Central Train Tracking system	Existing	Source for LRV location data.	SQL Server database query (e.g., indexed view).	N

Host System	Status	Data	Host System Interface	Implemented in STARNET?
Sacramento Regional Transit District, Incident Tracking System	In development by Regional Transit (RT)	Source for RT service disruption incidents.	SQL Server database query (e.g., indexed view).	N
Sacramento Regional Transit District (RT), Ridership Statistics System	Existing	Source for RT ridership statistics.	SQL Server database query (e.g., indexed view).	N
Yolo County Transit Management System	Existing	Source of incident and ridership statistics data.	SQL database query.	N
El Dorado County Transit Management System	Existing	Source of incident and ridership statistics data.	Incidents via e-mail. Ridership statistics via database read.	N
Sacramento County, VMS 330 traffic signal systems	Existing	Source for traffic signal and detector data.	Via the VMS 330 Proxy Server - format to be determined.	N
Sacramento County, ACTRA traffic signal system	Existing	Source for traffic signal and detector data, and signal commands. Sink for detector data and signal commands.	XML – based on NTCIP 2306 + TMDD.	N
City of Sacramento, TransSuite traffic signal system	Existing	Source for traffic signal and detector data, and signal commands. Sink for detector data and signal commands.	XML – based on NTCIP 2306 + TMDD.	N
City of Roseville, ATMS Now traffic signal system	Existing	Source for traffic signal and detector data. Sink for detector data.	XML or SQL database	N
City of Elk Grove, ATMS Now traffic signal system	Existing	Source for traffic signal and detector data. Sink for detector data.	XML or SQL database	N
City of Citrus Heights, traffic signal system	Existing	Source for traffic signal and detector data. Sink for detector data.	XML or SQL database	N
City of Sacramento, Parking Management System	Existing	Source for parking garage occupancy data.	To be determined – assume database read.	N
SACOG Transportation Planning Database	Existing	Sink for many data.	To be determined – assume XML push.	N
SACOG, Regional Transportation Management Display system (aka Regional Display)	To be provided by STARNET integrator	Source for incident data. Sink for most data.	To be determined by the STARNET integrator	Y
SACOG, 511 Telephone System	To be provided by others.	Sink for incidents, slowdowns and parking data.	To be determined. Assume XML push.	Y
Third Party Data Feed server.	To be provided by STARNET integrator	Sink for most data.	To be determined by the STARNET integrator.	Y

CCTV Cameras to be Implemented in STARNET

The initial implementation of STARNET was planned to provide operators (via the Regional Display web-browser-based interface) and the public (via the 511-web site) live streaming video from closed circuit television cameras per the following list. Per our count from http://traffic.sacregion511.org/ about 80 cameras are implemented. We do not have a detailed breakup of cameras from all cities, our visual analysis led us to

believe that most of the cameras are in City/County of Sacramento, City of Citrus Heights, and City of Rancho Cordova and City of Elk Grove. *This data has to be further verified by SACOG or Castle Rock.*

Table 13 - Proposed CCTV Camera Implementation Plan

Agency	Type of Camera	Approx. No. of Cameras Mid 2007	Interface Information	Implemented in STARNET
Caltrans District 3	Cohu analog Pan Tilt Zoom	20	Windows Media Services	Y
Sacramento County	Cohu analog Pan Tilt Zoom	44	Motion JPEG and Windows Media Services	Y
City of Sacramento	Analog Pan Tilt Zoom	30	Analog and TBD	Y
Roseville	IVC 3130-LL-NCS digital Pan Tilt Zoom with integral Axis encoder	70	Motion JPEG and MPEG-4	N
Citrus Heights	Cohu analog Pan Tilt Zoom	5	Analog	Y
Elk Grove	IVC 3130-LL-NCS digital Pan Tilt Zoom with integral Axis encoder	1	Motion JPEG and MPEG-4	Y
Regional Transit	Fixed	20 (of use to other agencies)	MPEG-4	N

Architectural Requirements

Following is a list of architectural requirements for STARNET. We do not have any information to confirm if these requirements are directly met. However, based on the logical system architecture diagram, we concluded that this is partially met. It is likely that the current architecture was adapted based on further discussion and changes, however those details are not available. *This analysis has to be further verified by SACOG or Castle Rock.*

- The System Requirements assume that the computer systems involved in STARNET are interconnected in a logical many-to-many network.
- STARNET has been implemented as a web-based system.
- Any computer system can obtain data directly from any other computer system, provided the data are available using internet protocols.
- There is no hierarchy or centralization.
- Therefore, at least initially, data will not flow between all computer systems, using a communications network
- The System Requirements assume that a computer system can establish a persistent request (subscription) with any other computer system to have real-time data automatically sent (published) either periodically or upon change.
- Data can flow continuously and without human involvement, other than establishment of data importers or subscriptions.
- A computer system may choose maintain control of what data are allowed to flow to what other computer systems.
- Each STARNET node is logically comprised of a “host system” and a “gateway” from which its data are accessed.
- The gateway provides STARNET interface functionality, including management of data imports and translation between STARNET and host system data formats and communication protocols.
- The host system provides the remainder of the functionality of that node.

- For existing host systems, the gateway will be provided by the STARNET system integrator and will likely function on a new computer separate from any computer used by the existing host system, hosted on the STARNET hosting platform.
- For new host systems being provided by the STARNET integrator (e.g., Regional Transportation Management Display system, and 511 system), the gateway may be integral with the host system.
- The gateways communicate with each other using a single standard protocol and message set. On the other hand, each node may use a different protocol and message set for “internal” communications between its gateway and its host system.

APPENDIX D – INDUSTRY REVIEW ADDITIONAL NOTES

SunGuide Freeway Management

Known as System Management for Advanced Roadway Technologies, SMART SunGuide is Florida Department of Transportation District Four's Intelligent Transportation System (ITS) Unit. SMART SunGuide is a system used to more effectively manage the highways. The system includes closed-circuit television cameras, electronic message signs, traffic detectors, and traveler information services such as 511.

A nationally recognized leader in Intelligent Transportation Systems, the Freeway Management Program operates out of the SMART SunGuide Regional Transportation Management Center (RTMC) 24 hours a day as an FDOT initiative that uses advanced technologies to manage traffic conditions along I-95, I-75 and I-595 in Broward, Palm Beach, Martin, St. Lucie and Indian River counties.

Operators at the RTMC coordinate with Road Rangers, Florida Highway Patrol and other RTMC partners to determine incident and congestion locations. Real-time traffic information is then posted to the public through Dynamic Message Signs, Highway Advisory Radio, the SMART SunGuide website and Florida's 511 Traveler System.

There are three steps that RTMC Operators must take to manage every incident.

STEP 1 Information Collection – By turning a camera getting information from Road Rangers or Florida Highway Patrol, TMC Operators are always monitoring the roadway in order to detect incidents.

STEP 2 Verification and Analysis – Once an event is verified, the details are entered into SunGuide, a traffic management software. These details are analyzed to determine the degree of disruption on the roadway and the potential impact on traffic.

STEP 3 Dissemination – The information is communicated to motorists using Dynamic Message Signs, Highway Advisory Radio and Florida's 511 Traveler Information. During events with a regional impact, neighboring centers including FDOT District Six TMC, Florida's Turnpike Enterprise TMC are contacted to coordinate a regional response.

SunGuide Arterial Management

The goal of FDOT District Four's TSM&O program is to provide a framework for active management of its transportation network. To achieve this goal, FDOT District Four established the Arterial Management Program (AMP) to actively monitor, manage, and improve arterial operations along major corridors in Broward and Palm Beach Counties in collaboration with the County Traffic Engineering Divisions. AMP strives to move vehicles and pedestrians quickly, efficiently, and safely along arterial roadways by using ITS tools throughout the District. AMP staff can monitor traffic conditions, detect incidents, and collect travel-time data in real-time. As the overall flow of traffic is actively monitored throughout the county, AMP staff provide support to County Signal Timing Engineers as they implement signal timing changes to improve traffic flow and reduce motorist delay. In addition, AMP staff also support FDOT District Four's Freeway ITS staff as they work together to improve freeway-arterial coordination during major incidents. Unlike the Freeway Management Program, AMP hours of operation are Monday through Friday from 7 AM to 7 PM, with reduced staffing during off-peak hours.

Services provided by SunGuide:

1. Road Ranger
2. Traffic Incident Management
3. Public Outreach
4. Severe Incident Response Vehicle
5. Express Lanes

SunGuide Public Outreach Material

Focused on communication and awareness, the Public Outreach team serves as the public's main source of traffic and construction information within the RTMC. The Public Outreach team frequently coordinates and participates in community outreach events, media interviews, private tours and meetings. To arrange a private tour or event, please visit contact us under Tour Request and fill out the electronic tour request form.

http://www.smartsunguide.com/#/publicOutreach

The Public Outreach Team of the SMART SunGuide RTMC publishes several outreach materials annually and quarterly; these materials are used to educate the public on the services and benefits of RTMC within private tours, meetings, media interviews and community outreach events. All outreach materials are available to the public for viewing or downloading.

Figure 2 - Outreach Materials by FDOT / SunGuide

An example of training material developed by NDOT.

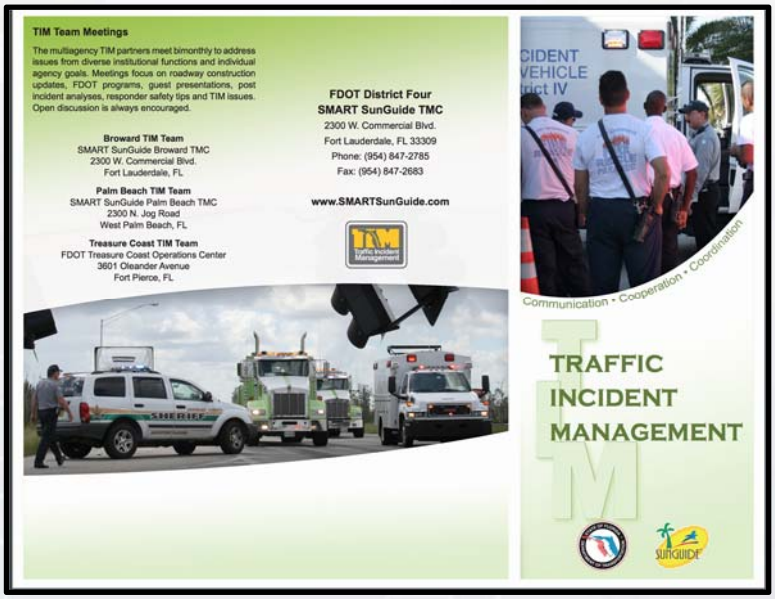
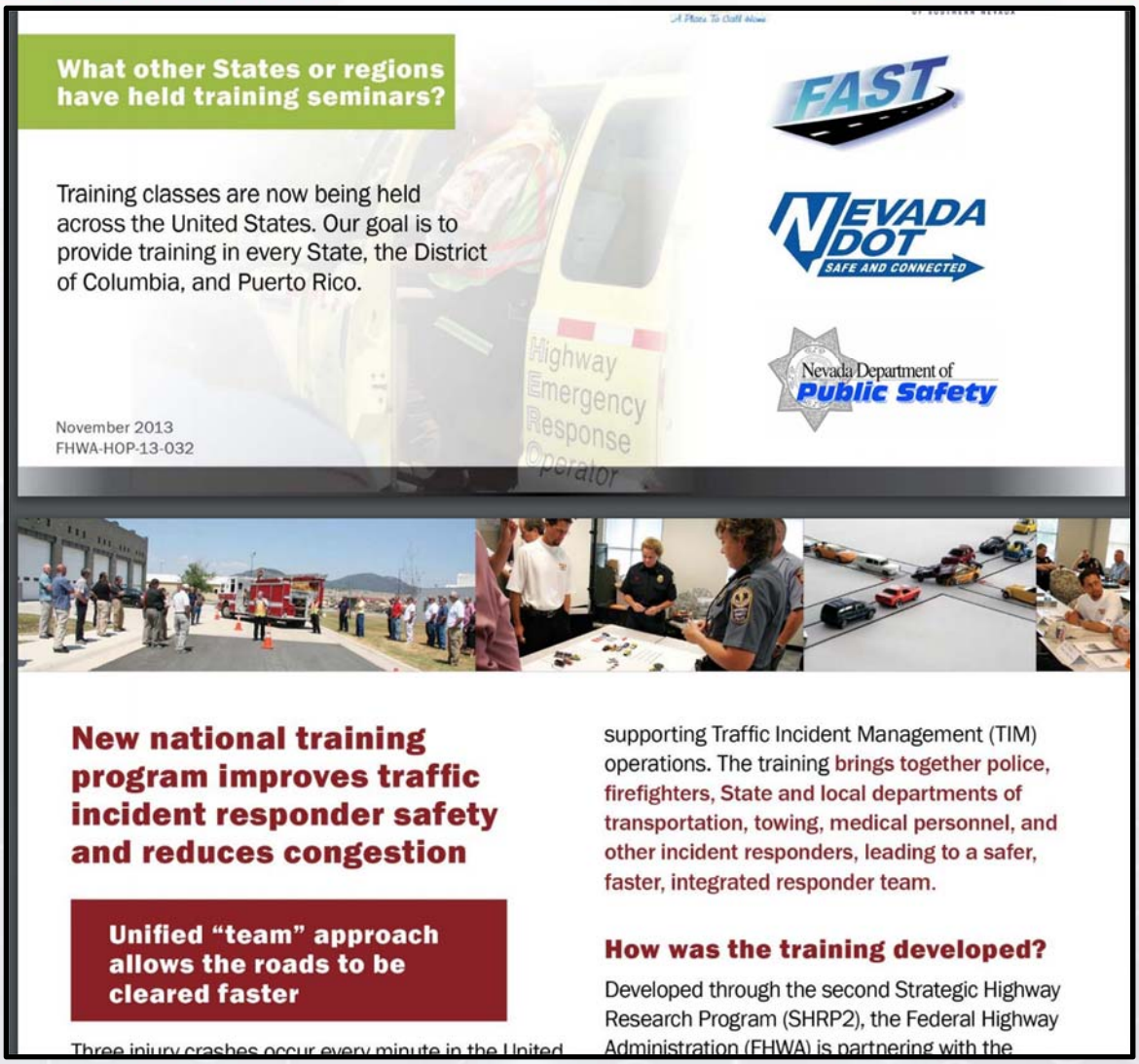


Figure 3 - Training Material Developed by NDOT



What other States or regions have held training seminars?

Training classes are now being held across the United States. Our goal is to provide training in every State, the District of Columbia, and Puerto Rico.

November 2013
FHWA-HOP-13-032

New national training program improves traffic incident responder safety and reduces congestion

Unified "team" approach allows the roads to be cleared faster

Three injury crashes occur every minute in the United

supporting Traffic Incident Management (TIM) operations. The training brings together police, firefighters, State and local departments of transportation, towing, medical personnel, and other incident responders, leading to a safer, faster, integrated responder team.

How was the training developed?

Developed through the second Strategic Highway Research Program (SHRP2), the Federal Highway Administration (FHWA) is partnering with the

Figure 4 - Nevada Training Brochure for Incident Response Training

APPENDIX E – TYPES OF AGREEMENTS USED IN LA RIITS

Table 14 - Types of Agreements Used in LA RIITS

ITS Service	Involved Stakeholder	Type of Agreement	Status	Description
Incident Management	LA County, Cities	Operational Agreement	Planned	Agreement describing the roles and responsibilities when an incident occurs
Regional Coordination	All agencies (such as local cities, Caltrans, LADOT, LACDPW, MTA)	Master Agreement	Planned	Agreement describing roles and responsibilities in case regional traffic coordination is required
Traffic Control	Cities	Inter-agency agreement	Planned	Agreement describing an agency controlling another agencies traffic signals
Emergency Vehicle Signal Pre-emption	Emergency Agencies, Local Cities, and County	MOU	Planned	Agreement describing emergency vehicle per-emption parameters
Transit Signal Priority and Countywide Signal Priority System	LA County, Cities, Metro Operations, Other Transit Agencies	MOU	Planned	Agreement describing signal priority parameters
Information Dissemination	LA County, Cities, Metro Operations, Caltrans	Inter-agency agreement	Planned	Agreement describing roles and responsibilities in information dissemination
Communication Infrastructure Maintenance	LA County, Cities	Funding Agreement	Planned	Agreement describing the funding sources and budget to maintain the ATIS infrastructure

APPENDIX F – SUMMARY OF STANDARDS FOR LOS ANGELES ATIS PROJECTS

Table 15 - Summary of Standards of Los Angeles ATIS Projects

Standard	Functional Area	Maturity
NTCIP 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1210, 1211	Global, Actuated Signal Controller, DMS, ESS, CCTV, Data Collection, Ramp Meter, Video Switches, Sensor Objects, Signal Systems Master, Signal Control Priority object definitions	Various levels (Global, Actuated Signal Controllers, DMS, ESS Approved, others Pre-ballot.
NTCIP 1102, 1104, 1105, 1106, 2104, 2202, 2303, 2304, 2305, 2501, 2502	Center-to-Center Standards Group	In various stages
NTCIP 1101, 1102, 1103, 2101, 2102, 2103, 2104, 2201, 2202, 2301, 2302, 2303	Center-to-Field Standards Group	In various stages
TMDD (TM 1.03, TM 2.01)	Traffic Management Data Dictionary, TMC Message sets	Being revised.
IEEE 1512	Standards for Traffic Incident Management Message	Balloting
NTCIP 1401-1408	Transit Management	Former TCIP standards. 1401-1407. 1408 (Fare collection) pre-ballot
SAE J2354	Message Set for Advanced Traveler Information System (AITS)	In development.

APPENDIX G – EXAMPLES OF PERFORMANCE REPORTS

Below are examples of reporting done by SunGuide and Broward county:

STATE OF FLORIDA • DEPARTMENT OF TRANSPORTATION

Quarterly Incident Duration

Performance Measures Report

Includes All Responders

District 4

Reporting Period: April 1, 2018 to June 30, 2018

SUNGUIDE® Florida's Intelligent Transportation System

Created on: July 02, 2018 8:33 am County: All Counties

Report Template version 3.0

Performance Measures Summary

	April	May	June	Total
Events included in Performance Measures	565	665	556	1,786
Notification Duration (min.)*	0.0	0.0	0.0	0.0
Verification Duration (min.)	1.7	2.1	1.8	1.9
Response Duration (min.)	4.4	4.0	3.7	4.1
Open Roads Duration (min.)	28.0	24.5	28.4	26.8
Departure Duration (min.)	26.5	27.1	25.7	26.5
Roadway Clearance Duration (min.)	**34.1**	**30.7**	**33.9**	**32.8**
Incident Clearance Duration (min.)	**60.6**	**57.8**	**59.6**	**59.3**

*FHP Data is not available for Notification Duration

Incident Clearance Duration

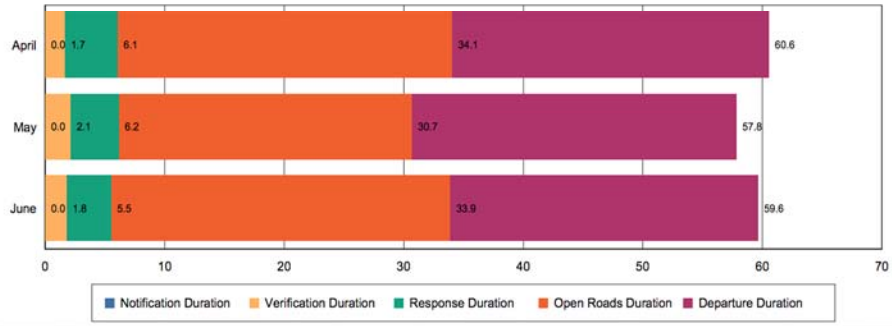


Table 16 - Quarterly Performance Measure Standard

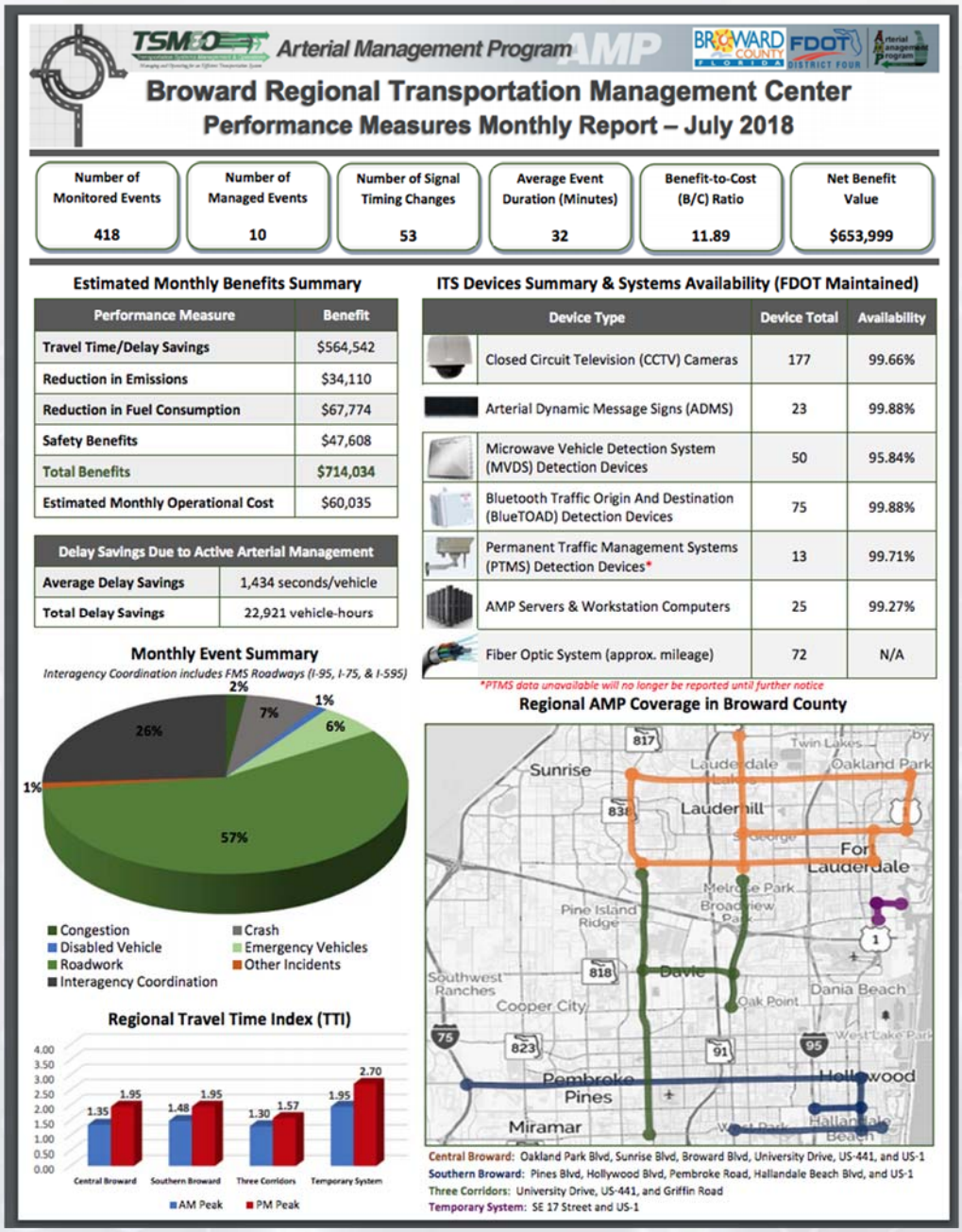


Figure 5 - Florida SunGuide: Arterial Level Performance Measures

APPENDIX H: STARNET AS DESIGNED AND ENVISIONED

This section describes STARNET as it was originally envisioned and designed per the STARNET Requirements document from October 2007.

Architecture and Data Flows

STARNET was envisioned to collect and distribute diverse sets of data to and from multiple stakeholders. The following diagram highlights STARNET as a group of data, data importers, and interfaces. Closed-Circuit Television Cameras (CCTV), Computer-Aided Dispatch (CAD), highway detectors, ramp meters, traffic signals, real-time transit information, transit vehicle location, and real-time parking data was expected to be collected and made available through operator interfaces as well as a public interface through 511-web and 511 telephone. Additionally, Extensible Markup Language (XML) interfaces were proposed for transporting data to a planning database to be set up by **SACOG**. A specific hosting solution was not proposed, but STARNET was expected to be easy to operate and made available to partner agencies and public users via phone and other means.

Figure 6 illustrates these data flows, infrastructure inputs, and interfaces.

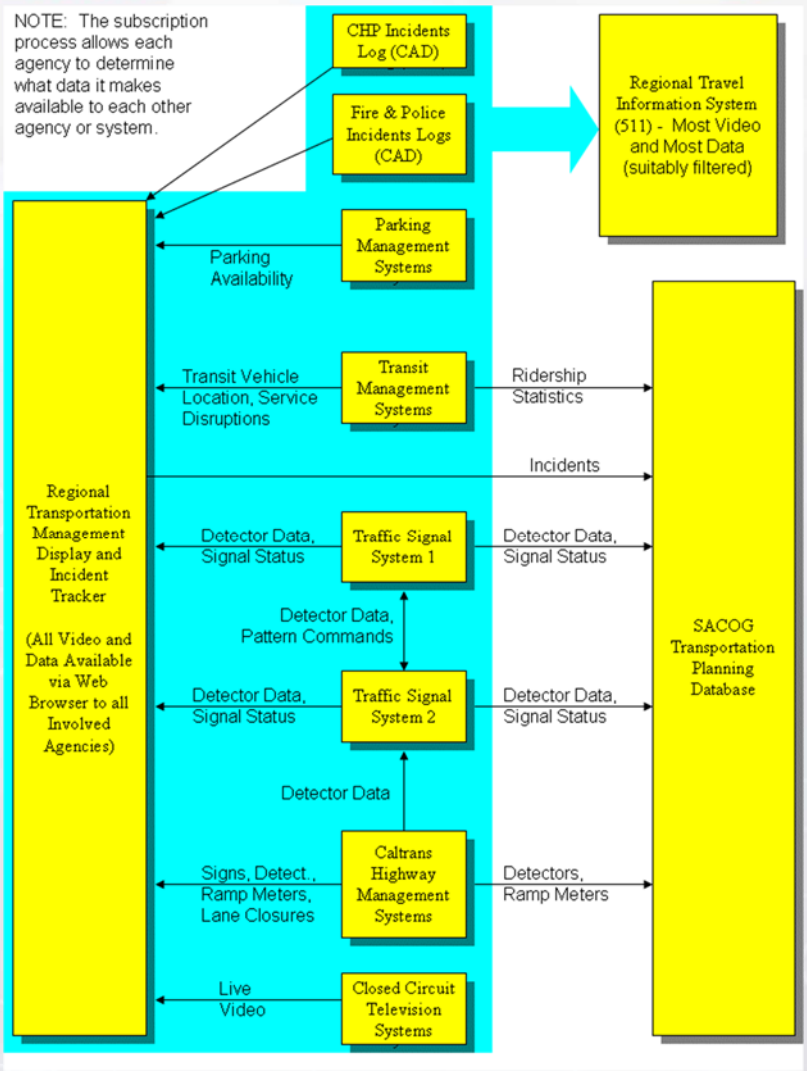


Figure 6 - STARNET Proposed Major Information Flows

(Source: STARNET Systems Requirements v1)

STARNET Stakeholders and Systems Used by Stakeholders

The following table lists major proposed STARNET stakeholders, their role, and their systems as proposed in the Concept of Operations document. STARNET was expected to collect data from these agencies.

Table 17 - Major Stakeholders / Data Providers for STARNET

Agency Name	Major Role	Types of Transportation Management Systems Operated or Planned by Stakeholder Agencies														
	*See key below	CAD	TMS	CMS	TSMS	LCS	TrMS (GPS, Fleet)	Trip Planning	CCTV	RTIS	MMS	311	PMS	Comm. Infra	Planning Database	Service Disruption Notification
California Highway Patrol.	LE, PS, FSP	x														
Caltrans District 3.	TM	x	x	x	x	x			x							
City of Citrus Heights	TM, PS				x				x							
El Dorado County	TM, PS				x											
El Dorado County Transit Authority	TrS						x									
City of Elk Grove (traffic and transit)	TM, TrS		x				x		x							
City of Folsom	TM, TrS, PS	x	x				x		x		x					
City of Rancho Cordova	TM, PS															
City of Rocklin	TM, PS															
City of Roseville (traffic and transit)	TM, TrS, PS	x	x				x	x	x		x					
City of Sacramento	TM, PS	x			x				x		x		x			
City of West Sacramento	TM, PS				x											
Sacramento Area Council of Governments (511 system, and transportation planning database).	Regional Transportation Planning and Funding, 511 Traveler Information System									x					x	

Agency Name	Major Role	Types of Transportation Management Systems Operated or Planned by Stakeholder Agencies														
Sacramento Regional Fire/EMS Communications Center	DF	x														
Sacramento County	TM, PS	x		x	x				x		x					
Sacramento Regional Transit District	TrS						x		x							x
Yolo County Communications Emergency Service Agency	DF, DP	x														
Yolo County Transportation District	TrS						x									

Legend: LE: Law Enforcement, PS: Public Safety, TM: Traffic Management, FSP: Freeway Service Patrol, TrS: Transit Service, DF: Dispatch Fire, DP: Dispatch Police

Table 18 presents a brief description of the transportation management systems expected to connect to STARNET and data collected by these systems at present.

Table 18 - Transportation Management Systems and Data Provided

Transportation Management System	Types of Data Collected	Data Available on STARNET	Data Load Method: Automated or Manual	Data Consumer	Notes
Computer Aided Dispatch (CAD) Systems	Highway incidents on highways	Y	Auto	Operators, Public	Shared by California Highway Patrol (CHP)/Caltrans to other agencies and public.
Waze	Highway incidents on highways and arterials	Y	Auto	Operators, Public	Waze did not exist when STARNET was first envisioned and thus it was not in the original Concept of Operations. However, the feed was identified as an ideal fit for STARNET after regional partnership was established through the Waze CCP (Connected Citizens Program)
Highway Traffic Management Systems (TMS)/Advanced Traffic Management Systems (ATMS)	Vehicle count, occupancy and speed	Y	--	Operators	Importer developed, and detectors/data made visible as a layer in STARNET. Displays are currently unavailable due to a software bug introduced during a back-end software update. The layer will be restored once a fix is in place- expected for January 2019.Made available to STARNET via front-end processors. However, this data import is temporarily turned off
Changeable Message Signs (CMS)	CMS data	Y	Auto	Operators, Public	No feed was made available to integrate into STARNET, nor was HAR integration identified as a target in the scope of work. Operated by Caltrans and cities.
Highway Advisory Radio (HAR)	Highway advisories	N	--	--	No feed was made available to integrate

					into STARNET, nor was HAR integration identified as a target in the scope of work. Operated by Caltrans.
Roadside Weather Information Systems	Wind speed/directions, precipitation, pavement temperature	N	--	--	No feed was made available to integrate into STARNET, nor was HAR integration identified as a target in the scope of work. Operated by Caltrans
Statewide Lane Closure System	Lane closure status	Y	Auto	Operators, Public	Data integration completed early in the project. However, Caltrans recently changed the data output format, which caused importer to break. Castle Rock has updated the importer to use the new data feed, and it is operational in staging. the update will be pushed to production as part of a January 2019 update. Web-based system.
Traffic Signal Management System (TSMS)	Current color, current timing mode, traffic volume (if available)	N	--	--	Operated by each agency separately
Transit Management Systems (TMS)	Automated Vehicle Location (AVL), trip planning, real time departures	Y	Auto	Public	Available from Sacramento Regional Transit
Closed Circuit Television Systems (CCTV)	Video feed (analog/digital), encoded	Y	Auto	Operators, Public	Available from CHP, Caltrans, Sac PD
Regional Travel Information System (RTIS)/511	Transit data, traffic incidents, 511 calls, ridesharing, bicycling	Y	Auto		
Maintenance Management Systems (MMS)	Real-time information on incidents that are disrupting traffic	Y	Auto/Manual		Operated by Caltrans and County of Sacramento
311	Non-emergency requests for repairs and other services	N			No feed was made available to integrate into STARNET, nor was 311 integration identified as a target in the scope of work.
Parking Management Systems	Parking availability of select garages	N			Operated by City of Sacramento no suitable data feeds or sources were identified in the

					initial integration phase of the project. STARNET integrator was advised to hold off on this development until regional architecture was complete. SACOG data feeds are now available and planned to be integrated under M&O.

STARNET Development

In 2005, SACOG awarded the technical assistance contract to Siemens to develop the Systems Engineering and Management Plan (SEMP), Concept of Operations, and System Requirements. Based on the user needs collected during the Concept of Operations phase, a detailed systems requirements document was created. Castle Rock was selected as the system integrator in March 2008. Based on system requirements, the detailed design was created in July 2009. STARNET was developed in 2009-2010 and put into production in December 2011. Not all modules were launched at that time, but many modules were added subsequently per agreements between SACOG and partner agencies and as data feeds became available.

Castle Rock is responsible for hosting, operating, and maintaining STARNET. STARNET is based on CARS (Condition Acquisition and Reporting System), a proprietary product developed by Castle Rock. During the implementation phase, many changes were made to the STARNET system requirements and tracked by the change management process. At the time of developing this document, “as-built” documentation for STARNET was not available. These as-built documents describe the implemented system. From conceptual development to implementation, there is no documentation that accounts for the changes that occurred between these stages in the process. Most of the information about the current system has been provided by Castle Rock as summarized in the ***Current STARNET*** section.

APPENDIX I: CURRENT STARNET (AS BUILT)

In this section, we describe how STARNET operates today. The STARNET system architecture describes modules used to build STARNET, communications networks, and user interfaces. STARNET has two types of interfaces: public and operator. STARNET is hosted in a hybrid cloud environment, which means that some of the hosting takes place in the cloud, while some takes place in a co-located data center.

Architecture

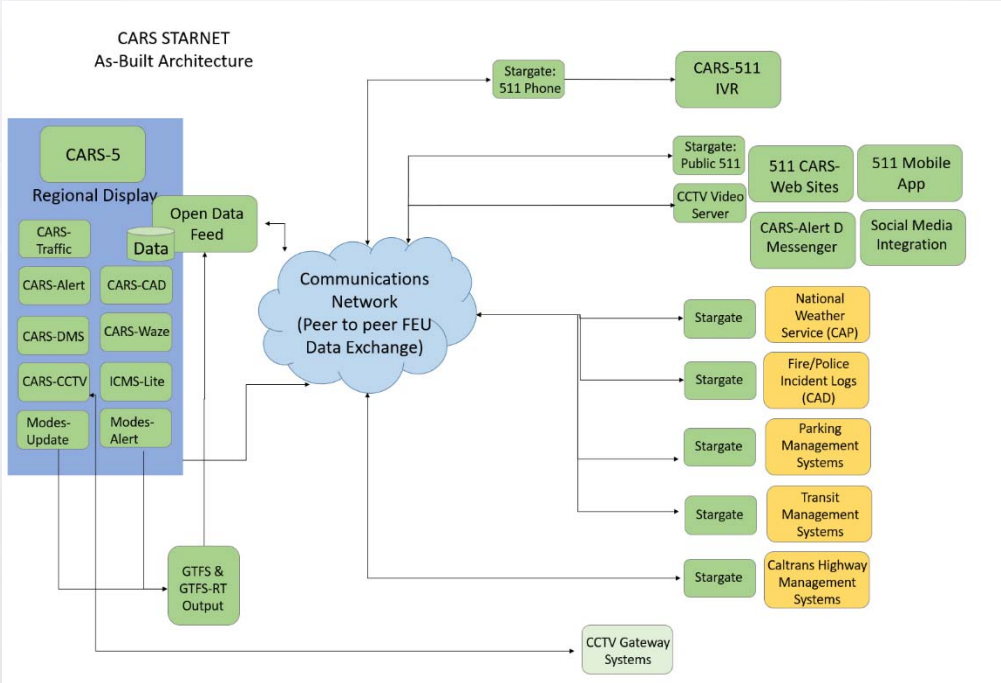


Figure 7 - STARNET System Architecture (Provided by Castle Rock)

Figure 7 illustrates the current design as developed and implemented by SACOG's system integrator. The left side of the diagram shows CARS operator interface, which contains information from Google Maps about traffic speed, incidents, CMS, alerts, and CCTV. The MODES modules (Modes-Alert and Modes-Update) enable SACOG transit partner agencies to create, manage, and maintain their transit data (GTFS and GTFS-real-time). This tool is designed for small to medium size agencies that don't have their own transit management system that can produce GTFS and GTFS-real-time. GTFS and GTFS-real-time data are consumed by Google, other third parties, and provide the basis of the transit trip planning function on Sacramento 511.

At present, signal data is not available through the operator interface. The STARNET system integrator was unable to identify a viable real-time data source for traffic signals to leverage during the integrations phase of the project. CARS collect various data sets either directly from field devices (such as CCTV) or via modules designed to collect specific data sets, such as transit management data, CAD data, Waze data, etc. These data sets are converted to ITS standard formats and stored temporarily in a database. All interfaces (operator or public) retrieve data from this database. STARNET also provides data over the phone after converting

incidents and other reports to audio files using IVR systems, as well as presented to the public through a web and app interface.

Table 19 lists all STARNET modules and interfaces:

Table 19 - STARNET Modules and Interfaces

Module/Interface Name	Use of Module/Interface
Incident Creator/Editor	Able to create incidents using maps and publish it on all channels
StarGates	Various modules import data (events, etc.) from various formats to ITS standards
CHP Incident Importer	Imports incidents from CHP CAD
WAZE Importer	Imports incidents from WAZE
Sacramento Police Department Incidents	Imports incidents from Sacramento Police Department
Lane Control System (LCS) Module	Imports lane closure data from Caltrans
Performance Measurement System (PeMS) Importer (Disabled)	Imports station data from PeMS, but currently disabled as traffic data is now coming from Google
Camera Feed	Imports multi-agency camera feeds
Caltrans ATMS Importer	Imports CMS
Modes Update	Create General Transit Feed Specification (GTFS) data for transit agency
Modes Alerts	Create alerts for Google GTFS-RT Feeds
511 Trip Planner	Creates transit trips
511 Apps	Android and iPhone Apps available from App Store
ICMS-Lite	Tracks incidents and generates statistics for incident duration
Alerts	Users can subscribe to alerts and save trips
Social Media	Publishes alerts on Twitter
511 Web	Provides all information on a public web portal
511 Phone System	Provides information on 511 phone systems
User Admin Module	Adds agencies and users
Logs Module	Logs usage statistics for agency portals
XML Feed	Publishes XML feeds for end users
Parking Data (Planned)	Planned to import real-time parking availability information
Bikeshare Data (planned)	Planned to import bikeshare data

Figure 8 shows logical flow of data from data sources to regional operator interface and then to public interfaces. The left section of the diagram represents multiple data sources currently imported into STARNET.

The middle section provides a list of operator interfaces made available by STARNET. CARS represent the regional operator's interface, which is what is available to each agency. A new agency is created using the agency/user administration module. Once an account is established for an agency, an agency administrator account is also established. The agency administrator then can create additional user accounts and set up data sources, such as cameras. CARS interface is a Google Map-based interface that supports creating and editing traffic events.

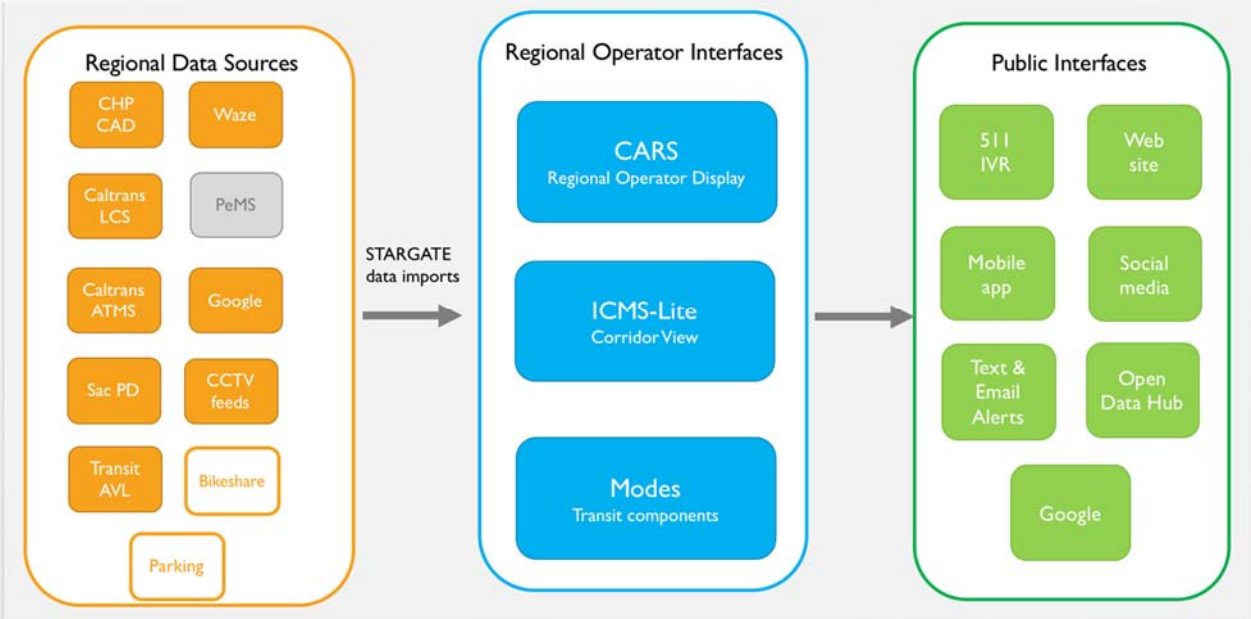


Figure 8 - STARNET Data Sources and Interfaces

When a user logs into the CARS module, users see a Google Maps-based view showing superimposed data layers, including cameras, CMS, incidents, construction work, and other data as available. **Figure 5** shows the regional operator interfaces and public interfaces available for STARNET users. Agency users can also create traffic incidents using this interface.

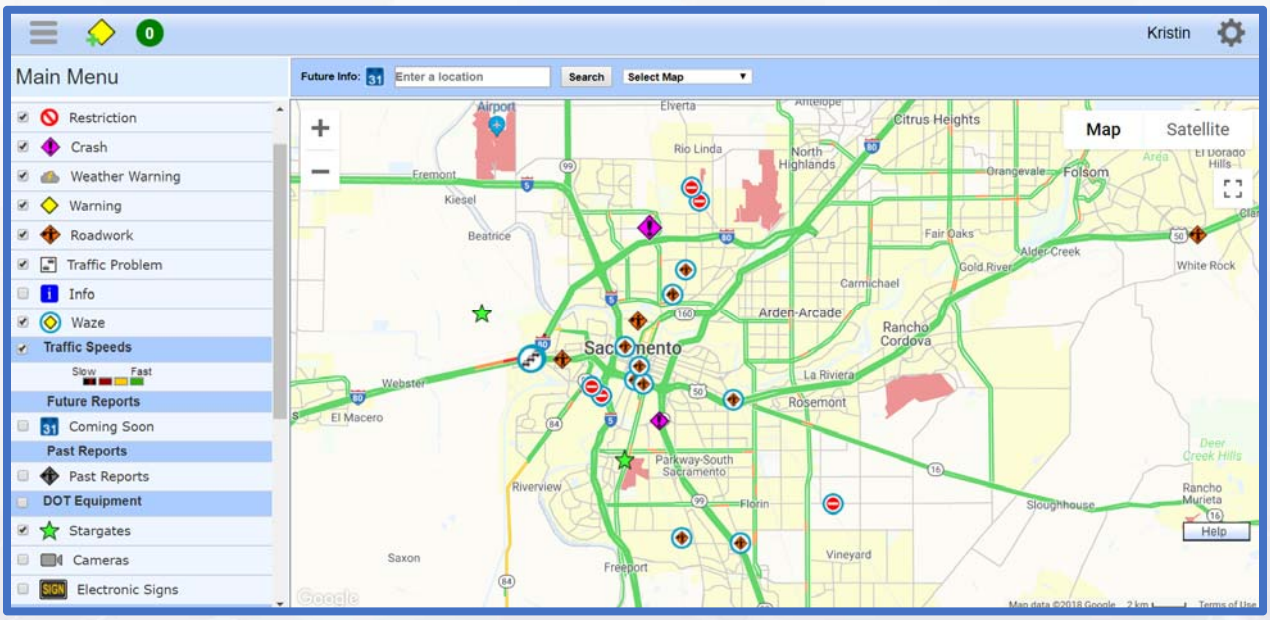


Figure 9 - STARNET CARS Interface

STARNET Hosting

STARNET is built on a *hybrid cloud architecture* that includes three distribution centers: Amazon Web Service (AWS), iLand (a cloud service provider), and Pittock Data Center. It includes an automated disaster recovery program referred to as DRaaS, which is powered by Zerto and operated on iLand. Through the DRaaS service, all CARS data is backed up to a cloud provider using a "trickle update method" that can become the primary operational hosting center in the event of a catastrophic failure at Pittock.

STARNET AWS architecture is captured below in Figure 9. This hybrid architecture now supports public platforms including 511 by pulling real-time data from CARS system deployments from the Pittock data center. Together, Pittock and AWS supported most CARS-based 511 web, phone, social media, and app traffic. iLand is now being used primarily as a disaster recovery site (using Zerto software) and for external system monitoring.

Table **20 and Figure 10** illustrate where major STARNET components are hosted:

Table 20 - STARNET Hosting Environment

Pittock Data Center	Amazon Web Services (AWS)	iLand
• Stargate modules • CARS • SQL Server Database to store incidents	Public-facing applications such as 511 web, XML, 511 phone, social media modules	Disaster recovery and external system monitoring

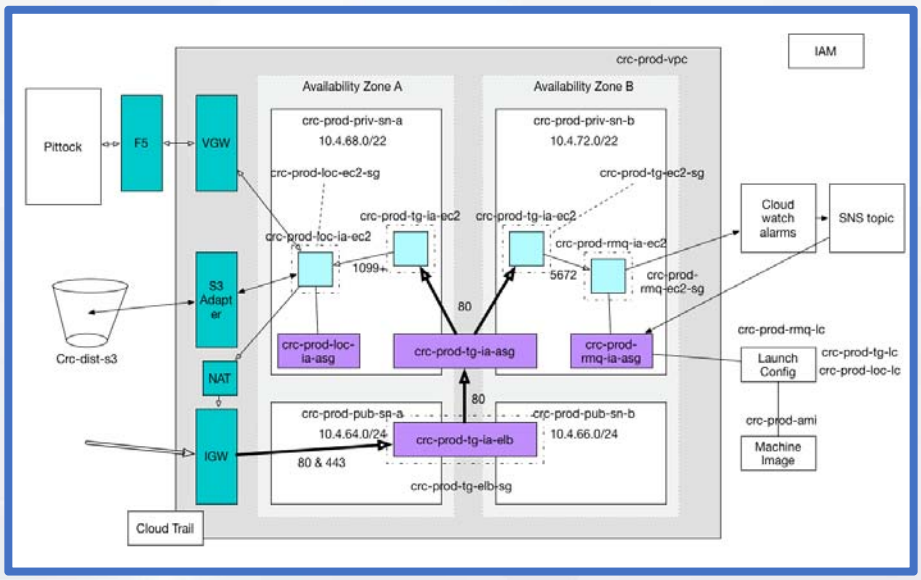


Figure 10 - Current CARS Architecture on AWS Platform

SACOG hosted STARNET infrastructure equipment at the Rancho Cordova hosting center through December 2017. However, this data center is now decommissioned. STARNET equipment currently hosted in data centers will be migrated fully to AWS by June 2019. STARNET is expected to be hosted exclusively in AWS by June 2019.

STARNET Users

Castle Rock, the system integrator for STARNET, has made STARNET licenses available to all partner agencies within SACOG. STARNET's user management module allows Castle Rock to add an agency to STARNET and then add users for that agency with specific user access levels, such as agency administrator. The user management module provides additional features, such as the ability to add a camera to STARNET.

At present, STARNET has more than 100 user accounts, but only a few accounts are used frequently. Based on feedback received, the following users currently use the STARNET operator interface or Modes modules:

- Sacramento Police Department: (Also provides incident data)
- Caltrans: (Also provides CAD data, road closure data, CMS, traffic detector data, weather data, etc.)
- CHP: (Also provides Incident data)
- City of Folsom: (Also provides Incident data)
- City of Roseville: (Also provides Incident data)
- Sacramento Regional Transit: (Also provides GTFS and GTFS-RT data).
- YoloBus Transit (uses Modes-alert)
- Yuba-Sutter Transit (uses Modes-Alert to create (GTFS-realtime)
- Placer County Transit 9uses Modes-Update to create GTFS)
- Tahoe Truckee Area Regional transit (uses Modes-Update to create GTFS)
- City of Elk grove transit (uses Modes-Update to create GTFS)

As listed in Table 1, STARNET was expected to be used by at least 16 agencies. However, based on the current list, only a subset of agencies are using it.

Data Collected/Stored/Distributed by STARNET
Automated Data Feeds: STARNET has developed Stargate modules to collect data from the following data providers:

1. CHP/Agency CAD (Incident data, lane closures)
2. WAZE incidents data
3. Google traffic feed
4. Caltrans traffic feed
5. Cameras by Caltrans (District 3), City/County of Sacramento, City of Citrus Heights, City of Rancho Cordova, and City of Elk Grove
6. Caltrans lane closure feed
7. Caltrans CMS feed
8. In progress; SACOG is in the process of developing modules to import parking data, now that a preliminary data feed has been established
9. In progress: SACOG is in the process of developing modules to import transit data, schedule (route, trips, stops, fares) and real time (departure times, alerts, and vehicle locations) from following agencies:
    1. Transit data from Sacramento Regional Transit (Schedule data (static), and real time)
    2. City of Roseville,
    3. City of Elk Grove

The STARNET system is designed to be a real-time data provider and visualization system; thus, it does not hold all data. However, for reporting purposes, some raw data along with information collected by aggregating data is stored 90 days.

STARNET has the functionality to create reports regarding existing data using the CARS Logs module. CARS also have an XML interface and API through which third parties may consume data in real time. The XML data is available from http://sa.carsprogram.org/hub/index.jsf.

Figure 11 illustrates XML Hub, which is named CARS Hub. Data are also available in a REST API.

CARS-Hub

This service is provided by the Sacramento Area Council of Governments.

Document Type	Document Link	Document Schema
FEU-t	data/feu-t.xml	schemas/FEU-t.xsd
FEU-g	data/feu-g.xml	schemas/FEU-g.xsd
FEU-m	data/feu-m.xml	schemas/FEU-m.xsd
FEU-t (indexed)	data/feu-t/index	schemas/FEU-index.xsd
FEU-g (indexed)	data/feu-g/index	schemas/FEU-index.xsd
FEU-i (indexed)	data/feu-i/index	schemas/FEU-index.xsd
FEU-m (indexed)	data/feu-m/index	schemas/FEU-index.xsd
CCTV	data/cctv.xml	schemas/CCTV.xsd
Traffic Inventory	data/traffic/inventory.xml	schemas/Traffic.xsd
Traffic Data	data/traffic/data.xml	schemas/Traffic.xsd

Figure 11 - CARS-Hub with a List of Available Data Feeds

SACOG had originally planned to archive all published data from STARNET in its own planning database for analyzing short- and long-term planning. Castle rock had proposed a work module to integrate the system with SACOG's regional database. However, this task was cancelled in an amendment as SACOG indicated that the regional data warehouse development had been indefinitely postponed.

Process to Add an Agency or New Data Stream

As mentioned above STARNET system imports data from agencies using data-specific modules. For all data that is provided by STARNET currently, a Stargate module is developed. Each Stargate module listens to the interfaces publishing data from the agency, converts it into ITS standards, and integrates it into the STARNET architecture. The following high-level process is followed to integrate new data streams into STARNET:

1. An agency expresses willingness to share a specific set of data (e.g., real-time transit data),
2. SACOG works with Castle Rock and develops a scope of work to import the data via STARNET.
3. SACOG consultants develop the necessary modules (Stargates) and procedures to import, save, and distribute data.
4. The developed processes are tested by the agency.
5. The data stream integration and distribution are automated.
6. SACOG consultants coordinate with the relevant agency to resolve any errors.
7. Castle Rock provides training if needed to applicable agencies.

Data importer modules need to be developed, or existing modules need to be updated or reconfigured, in order for STARNET to consume any new data source. Very few agencies have the ability to generate data in accordance with standards defined by ITS or Institute of Electrical and Electronics Engineers (IEEE). Hence,

importing any new data source is a new task, and SACOG is required to fund new tasks for system integrators and coordination between SACOG, the system integrator, and the agency submitting the data.

For agencies that wish to use the transit data components (Modes-Alert or Modes-Update) the process is as follows:

1. An agency expresses willingness and commitment to developing and maintaining their GTFS and/or GTFS-real-time data.
2. Castle Rock provides training materials, webinar training sessions, and follow up support to the agency.
3. Castle Rock provides ongoing M&O and helpdesk support to agencies as they use Modes-Update or Modes-Alert as part of normal operations.

STARNET Usage

As mentioned above, STARNET has multiple interfaces, operators only and public. As such, their usage is tracked and collected differently. **Figure 12** shows a list of STARNET related interfaces and their usage, which is tracked in Google analytics. Note that analytics have not been tracked for the Modes operator components.

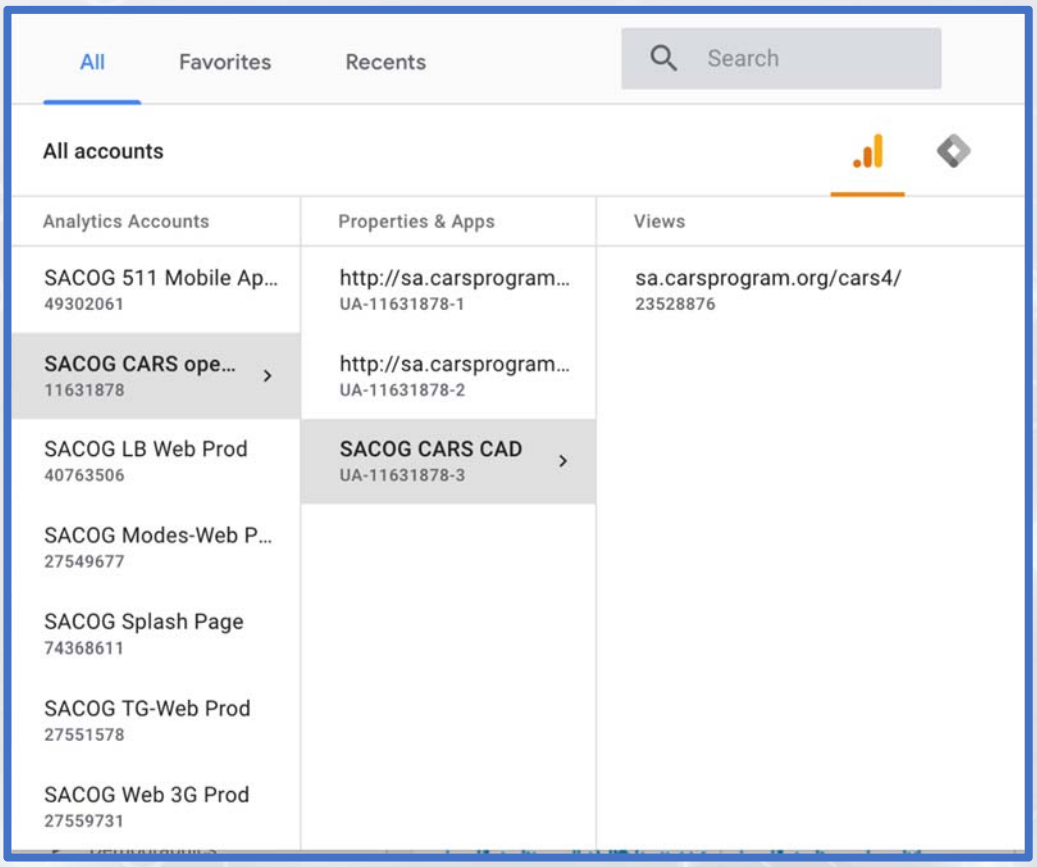


Figure 12 - STARNET Interfaces Tracked with Google Analytics

As STARNET has multiple interfaces, determining usage of STARNET involves looking at analytics for several system components- some public-facing, some operator-only, which are tracked separately. **Table 21** and **Table 22** show the usage over the last year for STARNET. This data may also reflect calls made for non-STARNET functions:

Table 21 - 511 Call Volume: April 2017 - March 2018 (Active Agencies) (Source: Castle Rock)

Agency	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Total Calls	% splits
SACOG	13,105	9,188	9,243	9,891	8,978	8,682	9,852	10,477	8,713	12,753	12,606	24161	***137,649***	

These call volumes are consistent with what many agencies have seen on their call platforms in recent years. As points of comparison, the following are 2017-2018 call volumes for other 511 phone systems:
Idaho: 114,883
Indiana: 88,210
Iowa: 113,921
Louisiana: 156,124
Minnesota: 141,063
Nebraska: 154,650
San Diego: 250,727

Table 22 - CARS (all interfaces) Usage by Agency (Source: Castle Rock)

Agency	4/17	5/17	6/17	7/17	8/17	9/17	10/17	11/17	12/17	1/18	2/18	3/18	Apr 2017 - Mar 2018 Total	2017-18 (12 mo. %)
SACOG	**2,104**	**1,581**	**1,485**	**1,602**	**1,561**	**1,265**	**1,478**	**1,414**	**1,301**	**2,130**	**1,911**	**2,545**	**20,377**	**0.08%**

SACOG's system integrator has provided access to the Google Analytics site, where statistics for the CARS interface are tracked. **Table 23** shows statistics for January 2018 to September 2018, and for January 2017 to September 2018.

In 2018, 404 pageviews were created for CARS with a bounce rate of 63%. According to Google Analytics, at support.google.com, a *bounce* is "a single-page session on your site. In Analytics, a bounce is calculated specifically as a session that triggers only a single request to the Analytics server, such as when a user opens a single page on your site and then exits without triggering any other requests to the Analytics server during that session."

Table 23 - STARNET Usage Statistics

STARNET WEBSITE USAGE STATISTICS FROM 01/01/2017-09/30/2018								
Site Name	**# of Users**	**New Users**	**Total Sessions**	**Number of Sessions per User**	**Page views**	**Pages / Session**	**Avg. Session Duration**	**Bounce Rate**
SACOG 511 mobile app data	1304	1227	15458	11.85	88	<0.01	0:00:46	0.21%
CARS4	212	147	387	1.83	656	1.7	0:02:59	65.63%
sa.carsprogram.org/cad	0	0	0	0	0	0	0:00:00	0.00%
SACOG LB Web Prod/All Web Site Data	3213	3197	3590	1	6687	0.86	0:00:31	83.23%
SACOG Splash Page/All Web Site Data	712	709	780	1.1	971	1.24	0:00:58	84.74%
SACOG NG-Web Prod/SACOG NG-Web Prod	13462	13350	20193	1.5	28996	1.44	0:01:26	77.92%
SACOG Web 3G/SACOG Web 3G	745	736	1279	1.72	22285	17.42	0:02:12	43.20%

The statistics below demonstrate that the bounce rate of the CARS page was similar for 2018 and 2017–2018 at about 63%. That means that the CARS users who visited the page did not go beyond the landing page. Though it may sound high, this rate is not unusual- e.g., "*As a rule of thumb, a bounce rate in the range of 26 to 40 percent is excellent. 41 to 55 percent is roughly average. 56 to 70 percent is higher than average but may not be cause for alarm depending on the website"*[1]. The Page/Sessions metric indicates that the average user viewed 1.7 pages. With 654 page-views over a 20-month period, to the system averaged 33 page views per month. Given that the system has 28 stakeholders responsible for managing daily transportation operations, this number is surprisingly low. Similarly, only 153 users accessed the system during the same 2017–2018 timeframe, which equates to 7.5 users per month.

At the same time, as STARNET is an interactive, map-based web site and app with only one "page", this number is not surprising, as a single, extended session with STARNET (or similar map-based systems) is often this range, as navigating the map and clicking on icons does not cause an additional page view to be invoked.

The public-facing web sites have seen significantly more usage- and some agencies have indicated that they use the public-facing interface to get information rather than logging into STARNET. The web site includes versions for low-bandwidth and high-bandwidth access- the low bandwidth has seen 6,687 page-views during this period; the full-featured site 28,996, and the mobile site 22,285. And, as illustrated above, annual 511 IVR phone usage is in line with peer systems across the USA.

Figure 13 shows complete set of usage statistics based on Google analytics.

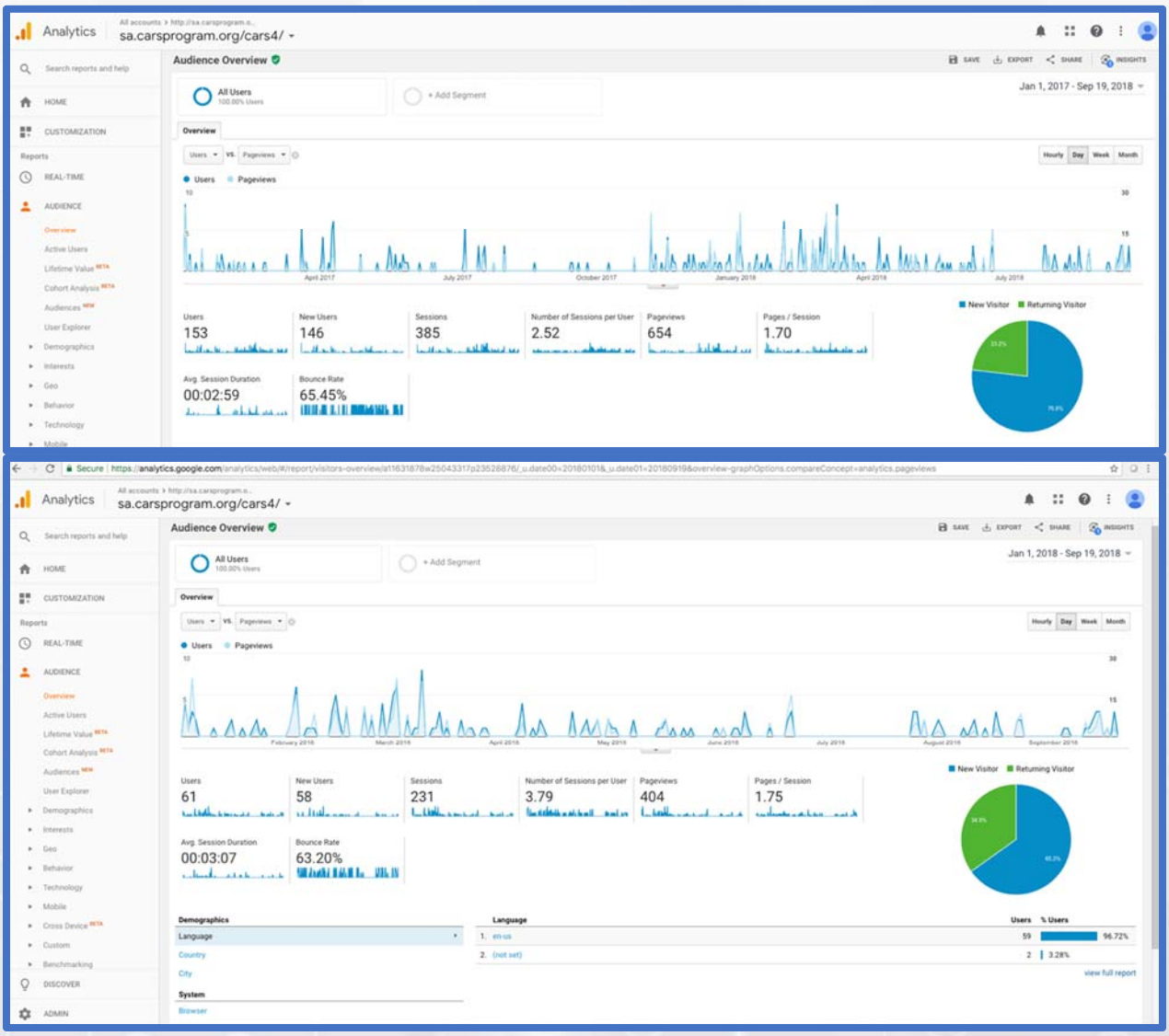


Figure 13 - Google Analytics: STARNET Operator Interface Usage Statistics

APPENDIX J: INDUSTRY REVIEW

In order to understand industry trends and best practices, a review of two systems with objectives similar to that of STARNET was conducted. This section provides high level details of these systems.

Los Angeles County RIITS

Introduction

The Los Angeles County Metropolitan Transportation Authority (Metro), serving the Los Angeles metropolitan area and parts of adjacent counties, is the region's largest transit agency with 1.3 million daily passengers across their multi-modal transportation network. Metro is considered the County's largest multi-modal network because it utilizes more than just buses and railways to connect users.

In 2004, Metro launched the Regional Integration of Intelligent Transportation Systems (RIITS) prototype as a demonstration project. This prototype was designed and developed in accordance with the Regional ITS architecture following the Systems Engineering Process and the National Intelligent Transportation Systems architecture to develop, integrate, store, share, manage, host, operate, maintain and expand the collection, distribution and use of transportation related data.

The RIITS program aggregates real-time data from ITS networks throughout the Los Angeles region and across jurisdictional boundaries to produce value-added data on multimodal transportation system operations to partner agencies and third-party information service providers (ISPs). RIITS complements other regional ITS networks by being a 'network of networks', thus it is also referred to as the system of systems. RIITS has the ability to integrate and disseminate transportation data from a variety of sources that include transit, freeway operations, arterial operations, commercial vehicles, ports, airports, and non-motorized transportation. Regional agencies recognize RIITS as an enabling tool for meeting Southern California's mobility, sustainability, and emergency management challenges.

RIITS is unique in that it does not implement many of the Service Packages defined within the National ITS Architecture but facilitates the center to center communications through the RIITS large area network and makes communication and transportation interfaces between source and destination centers.

Goals and Objectives

The RIITS vision statement affirms the purpose of RIITS is:

To deliver multimodal transportation information services through a flexible platform to achieve regional mobility, safety and sustainability goals.

RIITS' primary mission is to support the sharing of transportation data between and within organizations for the purpose of promoting operation and mobility improvements. RIITS has a flexible service platform and can tailor information delivery to a particular customer or agency's needs. RIITS has developed a unique position to serve these following objectives:

1. Operate regional inter-agency implementation of information sharing technology;
2. Bring together data from various transportation modes in a near real-time environment using modern technologies;

3. Function as the regional transportation data aggregator and clearinghouse;
4. Provide a strong institutional foundation for managing the configuration and development of the system without placing undue limitations on the participation of current and potential future partners; and
5. Provide the platform to support the investigation, analysis and development of technologies and solutions to improve transportation throughout the region.

Features and Functionality

The primary features and functionality are:

1. Provides real time information to partner agencies and public at its website, www.metro.net.
2. Provides an Information Exchange Network (IEN) that acts as communication backbone for data and video among agencies.
3. Hosts a regional ITS architecture group comprising of 11 agencies that is responsible for the system architecture.
4. Manages the project, provides leadership, and program level funding.

Lessons Learned

The following list summarizes some lessons learned in the implementation and operation of RIITS. Additional notes from the industry review are provided in **Appendix D**.

1. The LA Metro funds the RIITS program with an annual budget and a program manager responsible for overseeing the project. This gives the program manager the ability to add small projects as needed, given they fit into the regional vision.
2. Stakeholder engagement is key to the success of RIITS. RIITS has spent significant time and resources to engage stakeholders so that a strong relationship of trust is established. Per the LA Metro program manager, it takes about two years to establish a relationship with each agency.
3. RIITS has created five user categories based on their usage of the system. This helps them to engage the users, provide training, and address their needs.
4. Network Operations Plan is created and available.
5. Though a clear set of performance metrics is under development, RIITS uses qualitative parameters such usage of systems, improvements in the systems, ease and time taken to bring a new system online, ability to work with technology vendor, ability to integrate data from a system, and cost savings from collaboration, extending benefits of purchase of technology by one partner to all partners, etc.
6. RIITS places an emphasis on standards. RIITS defines the standards for technologies to be used in the project. Furthermore, RIITS works with vendors so that they can make their data available in the desired national standard. A list of standards used by RIITS is shown in **Appendix F**.
7. RIITS has established five types of agreements (examples of types of agreements used in RIITS is provided in **Appendix E**) that can be signed among agencies:
    1. Master Agreements: Agreement describing roles and responsibilities in case regional traffic coordination is required
    2. Operational Agreements: Agreement describing the roles and responsibilities when an incident occurs.
    3. Inter-agency Agreements: Agreement describing an agency controlling another agency's traffic signals.
    4. Memorandum of Understanding Agreement: Agreement describing emergency vehicle pre-emption parameters.
    5. Funding Agreements: Agreement describing the funding sources and budget to maintain the Advanced Traveler Information System (ATIS) infrastructure.

SunGuide of Florida

Introduction

In November 2001, the combined Florida and Michigan Departments of Transportation (DOT) *Transportation Management Center (TMC) Software Study* recommended the development of FDOT's SunGuide® software. SunGuide software enables Florida TMCs to integrate numerous hardware, software, and network applications as well as exchange data with other TMCs. Because SunGuide standardizes common TMC functions, it helps the various FDOT District facilities become more interoperable, so their systems operate better together. SunGuide software initially, and continually, leverages Texas DOT's original software investment, reducing Florida's costs.

SunGuide software is based on an open architecture and enables users to manage multiple subsystems. For example, TMC operators can use the software to perform incident management tasks, obtain data from vehicle detection systems, display videos from roadside cameras, and alert motorists with messages on dynamic message signs and highway advisory radio, or by using the Florida 511 (FL511) advanced traveler information system.

Mission

To continuously provide outstanding ITS products and services to our internal and external customers.

Goals and Objectives

Enhance the safety, security, and efficiency of Florida's transportation system through the implementation of interoperable ITS technology in support of local, regional, and statewide mobility.

Features and Functionality

SunGuide's primary features and functionality are:

- Allows TMC operators to monitor roadside sensors and closed-circuit television cameras to quickly and effectively detect, verify, respond to, and clear incidents.
- Provides real-time traffic information to the FL511 phone system and website at **www.fl511.com.**
- Standardizes data exchange between TMCs.
- Automates interface with the Florida Highway Patrol's computer-aided dispatch system to receive incident information.
- Uses an open architecture, making it easy to add new features.
- Complies with state and national standards, lowering costs and risks.
- Communicates with Road Ranger service patrol field computers.
- Supports 95 Express Lane dynamic pricing.
- Supports law enforcement with dissemination of AMBER (America's Missing Broadcast Emergency Response), SILVER (Alert Systems for Missing Seniors with impairment), and Florida's LEO (Law Enforcement Officer) alerts via dynamic message signs and FL511.
- Communicates with connected vehicle roadside infrastructure to receive traffic information and disseminate traffic advisory messages.

Devices Supported by SunGuide Software

SunGuide Software supports various devices, including:

- Dynamic message signs
- Variable speed limit signs

- Toll message signs (toll rate signs, lane status signs)
- Ramp signals
- Road weather information sensors
- Highway advisory radios
- Safety barrier cable system
- Closed-circuit television cameras
- Road sensors/detectors
- Video wall
- Toll equipment (license plate readers and automatic vehicle identification devices)
- Connected vehicle roadside infrastructure equipment

What are the Benefits?
Florida has 13 TMCs using the software, including FDOT Districts, toll authorities, and local agencies. For these agencies, the benefits of SunGuide include:

- Highly modular software design with easily expandable environment and high degree of supportability with evolving technologies.
- Lower risk through the use of state and national standards (e.g. National Transportation Communications for ITS Protocol).
- Uniform statewide performance measures.
- Lower software maintenance cost compared to maintenance of individual TMC software products.
- Less software training required due to use of common training materials; provides more qualified operations and maintenance personnel.

SunGuide Software Development Process
FDOT applied systems engineering throughout the SunGuide software development life cycle. Following the Venn diagram outlined in the *Florida System Engineering Management Plan*, each software release has gone through rigorous phases from Conception, Requirement Analysis, Design, Implementation, Integration and Testing, System Acceptance, Operation, and Maintenance.

SunGuide Software Users Group
A SunGuide Software User's Group was established to oversee and manage ITS deployments in Florida, with specific emphasis on implementing needed changes in a deliberate, controlled manner that takes into account the impact on regional and statewide systems. To see the meeting minutes from the SSUG meetings, visit the **SSUG page.**

SunGuide Software Features
The summary of SunGuide software features are provided in Table 24.

Table 24 - SunGuide Software Features

Release	Key Features	Release Year
6.0	Enhanced scheduled action subsystem and video on desktop, added configurable minimum number of volume for Traffic Sensor Station (TSS) alert, bulk update for AVL, updated logging of CCTV, DMS, Management and Analytics System (MAS), TSS, Systems Application Architecture (SAA), and Transmission Valid Timer (TVT), and dual support of Oracle and SQL Server databases.	**2013-2015**
6.1	Added beacon management subsystem, configuration file editor, CCTV driver, NTCIP version 2 &3, support for the Click!512 device to detect Wrong Way Driving incidents, and Nokia publisher to the SunGuide installation. Modified permission architecture, unified executive handler, and created RWIS simulator.	**2015-2016**
6.2	Added year field in vehicles, support for WAZE alert and BlueMAC devices, different Autofocus and AutoIris commands, and toggle settings for C2C devices. Modified Emergency Management (EM) to add sort order, DMS to force blank, and EM to allow comments through audit.	**2016-2017**
7.0	Added traffic control, managed lanes, and truck parking subsystems. Converted the administration dialog of AVL, CCTV, VS, DMS, EM, and TVT from admin editor to operator map. Converted AVL, CCTV, EM, SAA, TSS, and other subsystems to window presentation foundation (WPF) dialog in the operator map.	**2017-Present**

Usage of the System

The current and planned ITS device installation brings the total field inventory to over 700 ITS devices that cover approximately 200 centerline miles of managed roadways. The current count of ITS devices per category is listed in Table 25.

Table 25 - SunGuide Current Count of ITS Devices Per Category

FDOT District Six ITS Deployment								
Roadway	**CCTV***		**DMS**		**Detectors****		**Ramp Metering**	
	D	**UC**	**D**	**UC**	**D**	**UC**	**D**	**UC**
I-95	32	1	10	1	112		22	
I-95 Express	66	10	40	16	48	22		
SR 826	34	1	13		96	23		
I-75	9		3		32			
I-195	6		3		21			
I-395	8		2		11			
US 1 (Southwest 17 Ave to Southwest 112 Ave)	22		5		6			
US 1 (South of Florida City)	51		11		2			
Card Sound Road	5							
SR 9	1		1					
US 441	2		2					
Florida's Turnpike Spur	1		1					
Other Arterials	21	10	19	10				
Total	**258**	**22**	**110**	**27**	**328**	**45**	**22**	**0**

D = Deployed UC = Under Construction
**Includes static CCTV cameras for DMS verification.*
***I-95 detectors include ramp signaling loop detector stations.*

APPENDIX K: LIST OF DOCUMENTS PROVIDED BY SACOG STAKEHOLDERS

Table 26 - List of Documents Provided by SACOG Stakeholders

Document Name	Source	Date
STARNET System Verification Plan v0-2.doc	Doug Maas County of Sacramento	10/18/2018
STARNET High Level Design v0-1.doc	Doug Mass County of Sacramento	10/18/2018
STARNET Concept of Operations v1-0.doc	Doug Maas County of Sacramento	10/18/2018
STARNET Request for Proposals - Final.pdf	Doug Maas County of Sacramento	10/18/2018
STARNET Reliability Planning v0-2.doc	Doug Maas County of Sacramento	10/18/2018
STARNET Operations and Maintenance Plan v0-1.doc	Doug Maas County of Sacramento	10/18/2018
Notes from ITS Partnership 7 Mar 07.doc	Doug Maas County of Sacramento	10/18/2018
STARNET System Requirements Document v0-1.doc	Doug Maas County of Sacramento	10/18/2018
STARNET Procurement Plan v0-3.doc	Doug Maas County of Sacramento	10/18/2018
STARNET Stakeholders Cooperation Plan v1-0.doc	Doug Maas County of Sacramento	10/18/2018
STARNET Configuration Management Plan v1-0.doc	Doug Maas	10/18/2018

	County of Sacramento	
STARNET Documentation Plan v0-1.doc	Doug Maas County of Sacramento	10/18/2018
STARNET System Requirements Spreadsheet v0-1.xls	Doug Maas County of Sacramento	10/18/2018
STARNET Response to Questions 26Nov07.pdf	Doug Maas County of Sacramento	10/18/2018
STARNET Systems Integration Proposals Evaluation.doc	Doug Maas County of Sacramento	10/18/2018
M&O_Services_Castle_Rock_Associates.docx	Lauren Jenkins Castle Rock Associates	09/19/2018
Email from Dean Campbell @ STARNET Architecture	Dean Campbell Caltrans - District 3 TMC	10/18/2018
CARS-5-Training_01_du.doc	Lauren Jenkins Castle Rock Associates	09/18/2018
Email from Lauren Jenkins on 09:19:2018 STARNET Details.pdf	Lauren Jenkins Castle Rock Associates	09/19/2018
511 issues DM rev 7-12-2016.docx	Doug Maas County of Sacramento	06/27/2018
CARS CAD User Training Guide.pdf	Doug Maas County of Sacramento	06/27/2018
CARS 4 Training Guide.pdf	Doug Maas County of Sacramento	06/27/2018
STARNET Presentation Castle Rock-- September 2018 kv2.pptx	Lauren Jenkins	09/17/2018

	Castle Rock Associates	
Signed - SACOG-2008-01 - Original Agreement.pdf	Binu Abraham SACOG	10/17/2018
ITS MOU.pdf	Binu Abraham SACOG	10/17/2018
Third-Gen_CARS-Web_SystemDesign_67s_pd.docx	Kristin Virshbo Castle Rock Associates	10/22/2018
Modes Alert System Design Document_kv_11.docx	Kristin Virshbo Castle Rock Associates	10/22/2018
CARS-Imports_CAD_Mayday_SystemDesign_3_105_kv.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
CARS-5_SystemDesignDocument_18s_kv.docx	Kristin Virshbo Castle Rock Associates	10/22/2018
SACOG_PeMS_Stargate_1_ICD_16_kv.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
Requirements Table pd8.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
Modes-Update 1_95_sk.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
MODES_3_50_kv.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
STARNET Traffic Signal Control ICD.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
SACOG_CalTrans_CMS_ICD_S09_kv.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
SACOG_Lane-Closure-Stargate-12_ICD_13_abs.doc	Kristin Virshbo	10/22/2018

	Castle Rock Associates	
STARNET Traffic Signal Data Interface Control Document.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
SACOG_C.HP_CAD_ICD_07_kv.doc	Kristin Virshbo Castle Rock Associates	10/22/2018
SACOG_Amtrak_ICD_07_br.doc	Kristin Virshbo Castle Rock Associates	10/22/2018

APPENDIX L: EMERGING NEEDS OF STARNET STAKEHOLDERS

Table 27 - Emerging Needs of STARNET Stakeholders

Short Term Needs		Long-term Needs
Technical Needs	**Non-Technical Needs**	
• **Communication and Speed** o Provide fiber between cities and Caltrans o More reliable connections with all traffic signals o Establish connections to existing systems o Communication integration with bordering agencies o Utilize Hwy 50 fiber backbone • **Additional Data/Information** o Speed data for arterials o Real time bus information o Lane closures [Construction related closure] o Travel Times, o Police Dept. Requests for messages. o Travel time data o Locations for Electric Vehicle (EV) charging stations o Data form counters at roadside as well as at intersections. o Real time traffic data o detours and duration information. o Union Pacific data o Bike share locations o Road closures for rerouting transit vehicles. o Realtime parking information o Uber/Lyft options/data o Event Information and locations o Vehicle occupancy data o Corridor speeds o Ramp metering congestion o Bicycle detection o Pedestrian detection o Mobile-eye, pedestrian blind spot detection o Travel time data o Bicycle/Ped counts for planning purposes o Locations of charging stations for electric and hydrogen fuel vehicles o All local PD CAD Data o OD Data	• **Human Resource Related Needs** o More training for Operations and Maintenance (O&M) of IT systems. o Would like to receive staffing and skill recommendations based on city needs o Need more technicians with networking, systems knowledge o Will need training on how to utilize current systems more efficiently and effectively as funding for staffing decreases o Need recommendations for appropriate staffing levels to meet goals • **Inter-agency co-ordination** o Need to improve inter agency co-ordination o Share CCTV camera feeds with other agencies o Seasonal/special event management o Cross-jurisdictional incident data for active traffic management and notifications; rail locations that affect other delays o A vision for regional integration including policies, technologies and politics o Control of traffic signals, cameras, CSM signs of other agencies • **Efficiencies** o Consolidate Hosting for agencies. • **Other resource related needs** o TOC is location constrained. Space is an issue, • **Guidance** o Need assessment for existing CMS and recommendations for future CMS locations. o Enhancements for arterial/intersection performance metrics o Address staffing needs due to addition of new technology o Industry standards to reduce time to setup Emergency Operations Centers (EOC) o Operations and maintenance procedures document o There is a need to have some guidance on specific types of data that can be shared with other agencies. o Currently there is no process for active response planning. o Prioritize, advertise and encourage Transit options	• **Data** o All Traffic Signals o Weight in Motion (WIM) data o All ramp meters o Third party data (DaaS, real-time traffic monitoring) o Use of Google/WAZE for traffic data • **Emerging Technologies** o ICM-Virtual CMS, V2I, Connected/Autonomous Vehicle (CAV), o Need video bike/pedestrian detection system o Pilot project for autonomous vehicles o TDM project to use Lyft to get to transit o Monitoring all traffic signals which are unmonitored now • **Infrastructure** o County would like to place stationary CMS at few key locations. o As existing loops are not working well, county would like to switch from loops to cameras for detection. Considering combined camera/radar for detection. o Would like to have CCTV at major intersections o County desires upgrades to accessible pedestrian signals at intersections o A new CMS on Hwy 50 o Caltrans has Bluetooth detection along Hwy 50 o Increased automation o Once ICM is implemented, STARNET could be the backbone for communications. o Need loops and video to monitor arterial conditions

Short-Term Needs		Long-Term Needs
Technical Needs	**Non-Technical Needs**	
• **Improved Usability** ○ Notifications when cameras go offline. ○ Push notifications to adjacent agencies ○ Provide alerts to inform failing/under-performing equipment ○ Provide "viable alternative routes" ○ O-D data could be extremely useful to track vehicles throughout the Region. ○ Construction on local roadways ○ Convey generic delay messages to both adjacent travelers and waiting transit users. ○ Improved notifications unplanned events. • **Data Dissemination** • Disseminate information to public thru CMS	• **Policies and Documents** ○ O&M procedures document ○ Many agencies feel that there is no clear guidance on performance measures. ○ Congestion management strategies. ○ Need to improve flexibility and ability to share data across boundaries. ○ Better coordination with public safety agencies could improve response and closure times. ○ Proactive maintenance strategies • **Infrastructure Needs** ○ Integration of Caltrans and County intersections along key corridors • Notification from PD to Cities is a problem because communication network is not viable across jurisdictions.	• **New Interfaces** ○ Dashboards to summarize performance measures at City TMCs for real-time performance will be useful.